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THE BIOTIC PROVINCES OF MEXICO

BY EDWARD A. GOLDMAN AND ROBERT T. MOORE

The delimitation of the biotic areas of Mexico on a restricted regional basis has received attention from several zoologists in recent years. Most complete and most important is the work of Hobart M. Smith, in "An Analysis of the Biotic Provinces of Mexico, as Indicated by the Distribution of the Lizards of the Genus *Sceloporus*" (Sobretiro de los Anales de la Escuela Nacional de Ciencias Biologicas [Mexico], vol. 2, no. 1, pp. 95–110 [In English and Spanish], with map, 1940). An irregular line marking the boundary between the Nearctic and Neotropical regions of authors is drawn, and Mexico is divided by Smith into 23 biotic provinces. It is remarkable the extent to which these areas, based on the distribution of the species of a single widely ranging genus of reptiles, approximate in general boundaries those of major biotic units indicated as a result of our distributional analyses of the mammalian and avian faunas, and other considerations. The number of major areas recognized by us is 18, and the boundaries differ in detail as might be expected. The great unit to which we have given the name Transverse Volcanic Biotic Province is perhaps the most unconformable with any of Smith's provinces. An earlier treatment of the biotic provinces of Mexico by Smith (Zool. Series, Field Mus. Nat. Hist., vol. 26, pp. 14–22, with map) excluded Baja California.

In outlining "The Biotic Provinces of North America" Lee R. Dice (Univ. Michigan Press, Ann Arbor, pp. 78, with map, 1943) included the areas of northern Mexico with general boundaries, much as drawn by Smith. Faunal relationships and geographic distribution of mammals in Sonora were discussed and biotic provinces embraced in the state were segregated by W. H. Burt (Miscl. Publ. 39, Mus. Zool., Univ. Michigan, pp. 77, 26 maps, Feb. 14, 1938).

The northern and southern slopes of the same mountain may differ widely in floral and faunal character at the same altitude, owing to complex local conditions in parts of Mexico, and, as a result of the extreme diversity of environmental conditions presented, plant and animal associations of varying rank are almost innumerable. Many of these minor associations are easily recognizable as subdivisions of larger, more comprehensive units, but are omitted from formal discussion in the present connection. The larger units, denominated provinces, are regional areas embracing natural general groupings as shown by the analysis

of species and considerations that may include biotic relationships and geologic history. A major unit area may, therefore, be similar in topography throughout its extent and restricted to a single life zone, or it may be composed of both mountains and plains, with arid and humid sections, and several life zones may be included within the borders. Species listed are regarded as members of a characteristic assemblage, but are not necessarily confined to a single province in all cases. The areas are not all quite of coordinate rank, but are designed to present a nearly balanced concept of the major centers of distribution in the country as a whole. Islands reposing on the continental shelf, and often forming minor distribution areas in themselves, are obviously derived from and, therefore, with the exception of Guadalupe and the Revilla Gigedo islands, are included in the same province as the adjacent mainland. The Transverse Volcanic Biotic Province (see Moore, Trans. San Diego Soc. Nat. Hist., vol. 10, no. 12, pp. 217–256, 1945) is unique, occupying as it does the dominant geographic position and embracing the highest mountains on the continent south of Alaska.

Eighteen major biotic subdivisions of Mexico are recognized by us as follows:

1. California Biotic Province.
2. Guadalupe Island Biotic Province.
3. Vizcaino Desert Biotic Province.
4. Southern Baja California Biotic Province.
5. Revilla Gigedo Biotic Province.
6. Sonora Biotic Province.
7. Sierra Madre Occidental Biotic Province.
8. Chihuahua-Zacatecas Biotic Province.
9. Tamaulipas Biotic Province.
10. Sinaloa Biotic Province.
11. Nayarit-Guerrero Biotic Province.
12. Sierra Madre Oriental Biotic Province.
13. Transverse Volcanic Biotic Province.
14. Veracruz Biotic Province.
15. Sierra Madre del Sur Biotic Province.
16. Tehuantepec Biotic Province.
17. Chiapas Highlands Biotic Province.
18. Yucatan Peninsula Biotic Province.

The senior author is responsible for the botanical notes, selection of the mammals chosen as characteristic of each of the provinces, and for the names of provinces not hitherto employed by zoogeographers, with the exception of the Transverse Volcanic Biotic Province, the Guadalupe Island Biotic Province, and the Revilla Gigedo Biotic Province, the names of which were proposed by the junior and approved by the senior author. The junior author is responsible for the selection of the bird forms and has chosen chiefly those that are apparently confined as breeding birds to the provinces mentioned, with the exception of a few, which are specifically designated in the text as occurring in more than

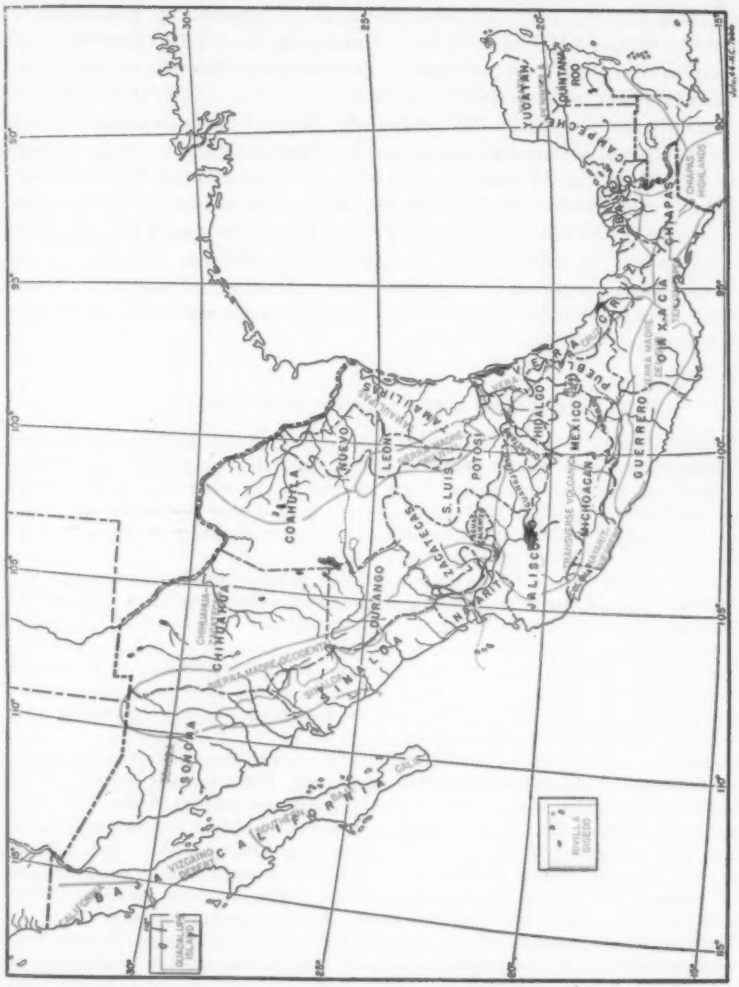

FIG. 1. Biotic Provinces of Mexico

one province. Mr. James L. Peters, of the Museum of Comparative Zoology, was very generous in permitting the authors to employ the nomenclature adopted by him in his unpublished manuscript of the Trochilidae for the *Birds of the World*. The map was prepared under the authors' direction by Katheryne C. Tabb, of the Fish and Wildlife Service. Throughout the article where the word "confined" is employed for a bird form, it does not mean that this form may not occur as a breeding bird in other countries than Mexico. Birds that appear in Mexico simply as migrants are not mentioned. Most of the more distant islands off the west coast of Mexico lack indigenous land mammals and are included here to show their characteristic bird-life. Guadalupe Island and the Revilla Gigedo Islands have such distinct species that they are ranked as biotic provinces, but our knowledge of the ecology of most of those nearer the coasts is incomplete and it seems best to regard them as within biotic districts. Because of the paucity of data for many of the provinces, the allocations of mammals, birds, and plants are admittedly tentative and subject to correction when further material becomes available.

DESCRIPTIVE LIST OF BIOTIC PROVINCES

1. **California Biotic Province.**—The California Biotic Province extends from southwestern California across the international boundary to include the Sierra Juarez and Sierra San Pedro Mártir and the western slopes of these mountains, extending down to the Pacific coast in northwestern Baja California. The southern limit is near latitude 30° 30′. It is an area of moderate rainfall, the lower slopes along the coast are in the Upper Austral and the higher levels extend into the Transition Zone.

The higher parts of the mountains are covered with a forest largely of yellow pine and sugar pine and many of the lower slopes are clothed with a dense growth of "manzanita" (*Arctostaphylos glauca*), "chamiso" (*Adenostoma fasciculatum*), "palo amarillo" (*A. sparsifolium*), and California holly (*Heteromeles arbutifolia*).

Among the characteristic mammals are: *Scapanus latimanus anthonyi, Sorex ornatus ornatus, Canis latrans clepticus, Felis concolor californica, Eutamias merriami obscurus, Neotoma fuscipes macrotis, Citellus beecheyi nudipes, Dipodomys gravipes, Peromyscus truei martirensis*, and *Odocoileus hemionus californicus*.

The birds that are apparently confined to this province are: *Anas platyrhynchos platyrhynchos, Gymnogyps californianus* (possibly extirpated), *Buteo lineatus elegans, Circus cyaneus hudsonius, Oreortyx picta confinis, Lophortyx californica plumbea, Rallus longirostris levipes, Colaptes chrysoides brunnescens, Dendrocopos scalaris eremicus, Sayornis saya quiescens, Nucifraga columbiana, Aphelocoma californica obscura, Parus gambeli atratus, Parus inornatus murinus, Psaltriparus minimus melanurus, Sitta pygmaea leuconucha, Heleodytes brunneicapillus bryanti, Toxostoma cinereum mearnsi, Sialia mexicana anabelae, Lanius ludovicianus grinnelli, Pipilo maculatus umbraticola, Junco oreganus townsendi*.

2. **Guadalupe Island Biotic Province.**—Guadalupe Island is located about 175 miles west of the northern third of Baja California. It is nearly 22 miles long and 3 to 6 miles wide, in the form of an unbroken volcanic ridge reaching to more than 4,500 feet above the sea. The island is surrounded by very deep water; between it and the mainland the depth is more than 2,000 fathoms. The ocean depths indicate that the island is the exposed crest of a mountain mass rising more than 16,500 feet above its base level on the sea bottom. The climate is similar to that of the California coast.

The flora is more nearly related to that of California than to that of Baja California. The trees include a pine (*Pinus radiata*), a cypress (*Cupressus guadalupensis*), and oaks

have been reported. A cabbage palm (*Erythea edulis*) occurs in small groves at low elevations.

No indigenous land mammals are known. Introduced goats and house mice have ravaged the vegetation to the point of extinction of some species. Introduced domestic cats led to the extinction of some of the native birds. The shores of the island were once favorite resorts for great numbers of the Guadalupe fur seal (*Arctocephalus townsendi*), and the sea otter (*Enhydra lutris nereis*), the former at least now believed to be extinct. Elephant seals (*Mirounga angustirostris*), sea lions (*Zalophus californianus*), and harbor seals (*Phoca richardii geronimensis*) still frequent its shores. Some of its land forms, such as *Colymbus nigricollis californicus*, also appear in the California Biotic Province, as well as in states of the west coast of the United States. Some like *Sitta canadensis canadensis* appear elsewhere only in the United States and Canada. Some are oceanic forms, which are not found in any other of the provinces of Mexico, but do appear elsewhere in the Pacific Ocean. The following birds seem to be confined to the island, or in the case of some extinct ones, to have been confined there in the past: *Polyborus lutosus* (now extinct), *Oceanodroma macrodactyla* (probably extinct), *Colaptes cafer rufipileus*, *Thryomanes bewickii brevicauda* (probably extinct), *Salpinctes obsoletus guadeloupensis*, *Regulus calendula obscurus*, *Carpodacus mexicanus amplus*, *Pipilo maculatus consobrinus* (probably extinct), *Junco oreganus insularis*.

3. **Vizcaino Desert Biotic Province.**—The Vizcaino Desert Biotic Province occupies the central desert section of Baja California, along with a desert strip extending north between the Gulf of California and the Sierra San Pedro Mártir into southeastern California. Included are islands along both the western and eastern coasts. It is a region of low, desert mountains and plains, and one of the most extremely arid in America. Owing to lack of moisture the vegetation is widely spaced.

The area lies wholly in the Lower Austral Zone, with the exception of Isla Cedros, which is nearly 4,000 feet high and extends into the Upper Austral Zone. The flora and fauna are derived mainly from California, but some remarkable species of plants are peculiar to the area. Among the dominant plants are: *Covillea tridentata*, *Fouquieria splendens*, *Idria columnaris*, *Pachycormus discolor*, and *Cercidium torreyanum*. Pines, junipers, and California holly (*Heteromeles*) are found on Isla Cedros.

Among the mammals are *Citellus leucurus leucurus*, *Citellus beecheyi rupinarum*, *Eutamias merriami meridionalis*, *Dipodomys merriami platycephalus*, *Dipodomys agilis peninsularis*, *Perognathus arenarius arenarius*, *Perognathus anthonyi*, *Antilocapra americana peninsularis*, *Ovis canadensis cremnobates*.

Some of the birds apparently confined to this province are *Brachyrhamphus craveri* (breeds on islands of the Gulf of California), *Otus asio cardonensis*, *Phalaenoptilus nuttallii hueyi* (occurs also in southeastern California), *Eremophila alpestris enerterus*, *Heleodytes brunneicapillus purus*, *Toxostoma lecontei arenicola*, *Geothlypis beldingi goldmani*, *Carpodacus mexicanus mcgregori* (confined to San Benito Island, casual on Cedros Island), *Pipilo fuscus aripolius*, *Passerculus sandwichensis anulus*, *Passerculus sandwichensis sanctorum* (confined to San Benito Islands), *Amphispiza belli cinerea*, *Melospiza melodia rivularis*. The following occur also in the next province: *Hylocharis xantusii*, *Toxostoma cinereum cinereum*, *Lanius ludovicianus netsoni*.

4. **Southern Baja California Biotic Province.**—To the Southern Baja California Biotic Province is assigned the southern section of Baja California from near latitude 27° to Cabo San Lucas and islands along the coasts. This somewhat diversified area is in the Arid Tropical Zone at the lower elevations, and extends into the Upper Austral Zone on the upper slopes of the mountains between La Paz and Cabo San Lucas. It is arid in general character, but moderate rainfall during the winter produces a much denser stand of vegetation than in the Vizcaino Desert Biotic Province, to which it is somewhat related. The mammals and birds are closely allied to those of southern California, but many have become differentiated within the area.

The tropical character of the area at the lower levels is shown by the presence along the coasts of the mangrove (*Rhizophora mangle*), *Conocarpus erecta*, the more generally dis-

tributed *Lysiloma candida*, *Albizzia occidentalis*, *Esenbeckia flava*, *Jatropha canescens*, and many others. The Upper Austral affinities of the mountains south of La Paz are shown by the occurrence of *Pinus cembroides*, *Quercus devia*, *Ribes brandegei*, *Heteromeles arbutifolia*, *Garrya salicifolia*, and *Arbutus peninsularis*.

Truly tropical mammals are limited mainly to a few bats, including *Natalus mexicanus*, *Dasypterus ega xanthinus*, and *Balantiopteryx plicata*, the latter found also on the mainland. Among other mammals peculiar to the area are *Pizonyx vivesi*, *Oryzomys peninsulae*, and *Lepus californicus xanti*. Restricted to the upper slopes of the mountains in the Upper Austral Zone are *Sorex ornatus lagunae*, *Thomomys bottae alticola*, *Peromyscus truei lagunae*, and *Neotoma lepida notia*.

Grinnell has shown that only three of the bird forms are of southern origin: "*Crotophaga sulcirostris pallidula*, *Hylocharis xantusii*, and *Dendroica erithachorides castaneiceps*." Some of the other bird forms apparently confined to this biotic area are: *Butorides virescens frazari*, *Otus asio xantusi*, *Bubo virginianus elachistus*, *Glaucidium gnoma hoskinsii*, *Chordeiles acutipennis inferior*, *Colaptes chrysoides chrysoides*, *Balanosphyra formicivora angustifrons*, *Dendrocopos scalaris lucasanus* (also on San Esteban Island), *Parus inornatus cineraceus*, *Sitta carolinensis lagunae*, *Heleodytes brunneicapillus affinis*, *Turdus migratorius confinus*, *Polioptila caerulea obscura* (also on San Esteban Island), *Lanius ludovicianus nelsoni* (also in the Vizcaino Desert Province), *Vireo huttoni cognatus*, *Geothlypis beldingi beldingi*, *Richmondena cardinalis ignea*, *Pipilo maculatus magnirostris*, *Pipilo fuscus albigula*, *Aimophila ruficeps sororia*, *Junco oreganus bairdi*.

5. **Revilla Gigedo Biotic Province.**—The Revilla Gigedo Islands, approximately 325 miles west of Cape Corrientes and approximately 250 miles south of Cape San Lucas in Baja California and comprising many islands much farther away, are so isolated that tentatively we have considered them as a biotic province until the ecology of the islands is more completely known. Some of the ornithological forms, not found elsewhere in Mexico, are herewith given: *Puffinus pacificus cuneatus* (breeds on San Benedicto Island and also on other islands of the central and eastern Pacific Ocean), *Puffinus auricularis* (also occurs from Cape San Lucas to Clipperton Island), *Sula dactylatra californica* (may breed on other islands), *Gygis alba* subsp. (Colony on O'Neal Rock near Socorro Island; found also on various islands of the Pacific Ocean). Apparently confined to Socorro Island are *Nyctanassa violacea gravirostris*, *Buteo jamaicensis socorroensis*, *Aratinga holochlora brevipes*, *Micrathene whitneyi graysoni*, *Pipilo maculatus carmani*. *Speotyto cunicularia rostrata*, *Troglodytes tanneri* seem to be confined to Clarion Island.

6. **Sonora Biotic Province.**—The Sonora Biotic Province embraces the desert plains region extending from southwestern Arizona south through western Sonora, gradually narrowing to a point on the coast in west-central Sinaloa. The low-lying plains are interrupted here and there by low desert mountains. It is an area of extreme aridity with desert plants widely spaced as a rule and typifying an arid western division of the Lower Austral Zone. In desert aspect it is similar to the Vizcaino Desert Biotic Province of central and northeastern Baja California (another section of the same life zone), many of the plants being the same. The fauna, however, differs widely in species composition and is largely derived from different sources.

A few characteristic plants are *Covillea tridentata*, *Fouquieria splendens*, *Cercidium torreyanum*, *Olneya tesota*, *Parosela spinosa*, and *Pachycereus pringlei*.

Among the mammals are *Pipistrellus hesperus hesperus*, *Canis latrans mearnsi*, *Taxidea taxus sonoriensis*, *Conepatus sonoriensis*, *Citellus harrisii harrisii*, *Dipodomys spectabilis perblandus*, *Perognathus baileyi baileyi*, *Perognathus penicillatus pricei*, *Odocoileus hemionus eremicus*, and *Ovis canadensis gaillardi*.

Some of the birds apparently confined to this province are: *Lophortyx gambelli fulvipectus*, *Lophortyx gambelli pembertoni* (apparently confined to Tiburón Island), *lophortyx douglasii bensoni* (also in Alamos District), *Eremophila alpestris leucansiptila*, *Auriparus flaviceps fraterculus*, *Heleodytes brunneicapillus brunneicapillus*, *Pipilo fuscus jamesi* (confined to Tiburón Island), *Aimophila carpalis carpalis* (rediscovered in Arizona), *Richmondena cardinalis superba*.

7. **Sierra Madre Occidental Biotic Province.**—The Sierra Madre Occidental Biotic Province occupies the massive area of the Sierra Madre Occidental which forms the continental backbone, extending from the international border southeasterly along the boundary lines between Sonora and Chihuahua, Sinaloa and Durango, to eastern Nayarit, western Zacatecas, and northern Jalisco. General conditions are fairly uniform throughout this lengthy area, which takes the form of a rolling plateau at 7,000 to 8,000 feet altitude, with the western side deeply cut by canyons draining to the Pacific coast. Here and there a few peaks rise 1,000 to 3,500 feet above the general level. The higher part lies chiefly in the Transition Zone, flanked by belts of Upper Austral Zone in the northern part and by arid Upper Tropical in the southern part. The climate is rather dry, although heavy rains are frequent during the summer and some snow falls on the upper slopes in winter and as late as May.

This province comprises at least three biotic districts. One in the extreme northwestern portion, consisting of a portion of northeastern Sonora, is of medium altitude and extends west as far as the 110th degree of longitude. It constitutes approximately the eastern half of Dr. Burt's Apachian Biotic Province, the employment of the name "Apache" having been used first by Mearns. This name seems to us inappropriate, as the Apaches were a wandering aggregation of tribes or bands who were hardly ever organized into definite tribes. Their most noted characteristic was their raiding disposition and the shifting of their locations. It is just the opposite sort of life from the sedentary type, which is the basic material with which the students of biotic provinces deal. Therefore, we suggest the abandonment of the name "Apachian" and the substitution of the name of the tribe which resided in this area, calling it the Opata Biotic District. It is a region of rolling country with hills rising into the foothills of the Sierra Madre.

The junior author (Moore, *op. cit.*) has named the other two districts, which reach to higher altitudes, the Tarahumare Biotic District and the Tepehuane Biotic District. The upper slopes of the mountains are covered mainly with forests of pine, oak, and madroño, with the "pinabete" (*Abies religiosa*), Douglas fir (*Pseudotsuga mucronata*), and quaking aspen (*Populus tremuloides*) appearing here and there in the colder places as Canadian Zone elements. At somewhat lower levels in the Upper Austral Zone, oaks and many shrubs, including the manzanita (*Arctostaphylos pungens*), become dominant.

Among the mammals are the black bear (*Euarctos americanus machetes*), grizzly bear (*Ursus nelsoni*), wolf (*Canis lupus baileyi*), puma (*Felis concolor azteca*), *Citellus madrensis*, *Sciurus aberti durangi*, *Sciurus apache apache*, and the white-tailed deer (*Odocoileus virginianus couesi*).

The Sierra Madre Occidental Biotic Province is rather rich in bird life. Not only many races are confined to it, but even the genus *Xenospiza*. Another, *Cyanocorax*, occurs nowhere else in Mexico and of a third, *Otophanes*, only a single specimen has been taken elsewhere. Some of the birds confined to this province are *Meleagris gallopavo onusta*, *Aratinga holochlora brewsteri*, *Amazona finschi woodi*, *Otus vinaceus vinaceus*, *Otus trichopsis aspersus*, *Asio stygius lambi*, *Otophanes mcleodii* (also in the Transverse Volcanic Province), *Atthis heloisa margarethae*, *Lampornis clemenciae bessophilus*, *Trogonurus mexicanus clarus*, *Balanosphyra formicivora aculeata*, *Campephilus imperialis* (also in the Transverse Volcanic Province), *Dendrocopos villosus icastus*, *arizonae arizonae*, *Empidonax affinis pulverius*, *Empidonax difficilis immodulatus*, *Empidonax albigularis timidus*, *Progne dominicensis sinaloae*, *Cyanocorax dickeyi*, *Aphelocoma californica grisea*, *Cyanocitta stelleri macrolopha*, *Parus sclateri eidos*, *Parus wollweberi annexus Myadestes townsendi calophonus*, *Turdus assimilis calliphthongus*, *Catharus aurantiirostris aenopennis*, *Catharus occidentalis olivascens*, *Sialia mexicana bairdi*, *Sialia mexicana amabile*, *Ptilogonys cinerues otofuscus*, *Vireo solitarius pinicolus*, *Vireo gilvus brewsteri*, *Dendroica auduboni nigrifrons*, *Ergaticus ruber melanauris*, *Hesperiphona abeillei pallida*, *Carpodacus mexicanus altitudinis*, *Atlapetes torquatus verecundus*, *Pipilo maculatus griseipygius*, *Melozone kieneri grisior*, *Plagiospiza superciliosa palliata*, *Xenospiza baileyi*, *Aimophila quinquestriata quinquestriata*, *Aimophila rufescens mcleodi*, *Aimophila ruficeps simulans*, *Junco phaeonotus palliatus*, *Spizella atrogularis evura* (also in U.S.), *Melospiza melodia goldmani*.

8. **Chihuahua-Zacatecas Biotic Province.**—The Chihuahua-Zacatecas Biotic Province covers the northern interior plains in Chihuahua, western Coahuila, Durango, Zacatecas, San Luis Potosí, and Aguascalientes, passing on the south into the Transverse Volcanic Biotic Province, and toward the northeast into the Tamaulipas Biotic Province to which the northern part is rather closely allied. It is an arid interior desert region consisting mainly of rolling plains, increasing gradually from 1,000 to 3,000 feet in altitude along the northern border to about 5,000 feet along the southern and western sides. Short ranges of desert mountains rise island-like above the general surface and a mountain group just south of the Big Bend of the Rio Grande reaches 10,000 feet in altitude. The general drainage is toward the Rio Grande, but a number of interior basins have no outlets.

Open grassland plains are interrupted by areas overgrown with "mezquite" (*Prosopis juliflora*), acacias of various species, "ocotillo" (*Fouquieria splendens*), "creosote" bush (*Covillea tridentata*), and many other desert shrubs, yuccas, agaves, and cacti, the latter including the large, conspicuous species *Myrtillocactus geometrizans*.

Among the mammals are the desert fox (*Vulpes macrotis zinseri*), Mexican prairie dog (*Cynomys mexicanus*), banner-tailed kangaroo rat (*Dipodomys spectabilis spectabilis*), *Dipodomys nelsoni*, Gaillard antelope jackrabbit (*Lepus gaillardi gaillardi*), Mexican pronghorn antelope (*Antilocapra americana mexicana*), and Mexican bighorn sheep (*Ovis canadensis mexicana*).

The bird forms apparently confined to this province are: *Anas diazi novimexicana*, *Mergus merganser americanus*, *Colaptes cafer collaris*, *Eremophila alpestris aphrastus*, *Vireo bellii medius*, *Toxostoma dorsale dumosum* (also in Transverse Biotic Province), *Chondestes grammacus strigatus*, *Amphispiza bilineata confinis*.

9. **Tamaulipas Biotic Province.**—The Tamaulipas Biotic Province comprises the lowland plains and a few isolated ranges of low mountains in eastern Coahuila, northern Nuevo Leon and Tamaulipas, except the southwestern part. The southern boundary is the line between the Nearctic and Neotropical regions. Along the southern side of the Rio Grande Valley this province passes toward the west with increasing altitude, imperceptibly at any particular point, into the Chihuahua-Zacatecas Biotic Province, and it is allied to the Sonora Biotic Province, but it should be noted that the indigenous bird-life does not indicate this as clearly as do the mammals and plants. From the low Gulf coastal plains of Tamaulipas the altitude within the area increases gradually to about 2,000 feet along the eastern flank of the Sierra Madre Oriental. Arid conditions prevail, as the moderate rainfall is abosrbed by limestone closely underlying much of the surface, and there are few streams. The province lies mainly in the Lower Austral Zone, invaded to some extent by tropical elements, a few of which reach as far north as the Rio Grande. Mixed conditions are due to nearly uniform low terrain and to frosts of killing severity to cold-sensitive plants and animals. The upper slopes of some of the mountains enter the lower part of the Upper Austral Zone.

The area is semi-arid and the vegetation is made up mainly of thorny shrubs and small trees with a liberal admixture of yuccas, agaves, and cacti. Among the plants are *Yucca australis*, *Atriplex matamorensis*, *Acacia wrightii*, *Pithecollobium flexicaule*, *Cercidium floridum*, *Eysenhardtia polystachya*, and *Covillea tridentata*.

Among the characteristic mammals are: *Canis latrans microdon*, *Felis pardalis albescens*, *Felis cacomitli*, *Neotoma micropus micropus*, *Citellus variegatus couchii*, *Liomys irroratus texensis*, *Perognathus hispidus hispidus*, *Pecari angulatus angulatus*, and *Dasypus novemcinctus texanus*.

The following forms of bird-life seem to be confined to this biotic province: *Colinus virginianus texanus* (also in U. S.), *Aratinga astec vicinalis*, *Otus asio semplei*, *Ciccaba virgata tamaulipensis*, *Amazilia yucatanensis chalconota*, *Xiphorhynchus striatigularis*, *Aphelocoma sordida couchii*, *Thryothorus ludovicianus berlandieri*, *Thryothorus ludovicianus lomitensis*, *Thryothorus rutilus microstictus*, *Toxostoma longirostre sennetti*, *Toxostoma curvirostre oberholseri*, *Polioptila melanura melanura*, *Geothlypis flavovelata*, *Icterus fuertesi*, *Icterus graduacauda audubonii* (also in Texas), *Icterus cucullatus sennetti* (also in Texas), *Sturnella magna*

hoopesi (also in Texas), *Cyanocompsa parellina beneplacita*, *Arremonops rufivirgatus rufivirgatus* (also in Texas), *Spizella wortheni*.

10. **Sinaloa Biotic Province.**—The Sinaloa Biotic Province occupies a northern extension of the Arid Tropical Zone from Sinaloa northward to the Yaqui River Valley along the lower western slopes of the Sierra Madre Occidental, but many of the tropical forms do not range north of the Río Fuerte in northern Sinaloa. From Central western Sinaloa northward it is separated from the coast by a narrow, southern extension of the Sonora Biotic Province in the Lower Austral Zone. Rains are fairly frequent in summer and light showers occur irregularly in winter, with frosts so slight as to be almost imperceptible. The area is semiarid in general character, the rainfall sufficient to produce a low forest of moderate density made up of trees 15 to 25 feet high.

Many of the plants, associated with distinctive forms of mammals and birds, are also found in tropical provinces to the southward, but do not occur regularly in the adjoining Sonora Province. Among the plants are *Ipomoea arborescens*, *Randia echinocarpa*, *Guazuma ulmifolia*, *Ceiba acuminata*, *Acacia cymbispina*, *Lysiloma divaricata*, and several species of wild fig.

Among the mammals are *Nasua narica pallida*, *Felis onca arizonensis*, *Felis pardalis sonoriensis*, *Felis yaguaroundi tolteca*, *Teanopus phenax*, *Pecari angulatus sonoriensis*, and *Odocoileus virginianus sinaloae*.

Among the forms of bird-life apparently confined to this province are *Geranospiza nigra livens*, *Ortalis wagleri griseiceps*, *Lophortyx douglasii douglasii*, *Forpus cyanopygius pallidus*, *Otus guatemalae tomlini*, *Glaucidium minutissimum oberholseri*, *Momotus mexicanus vanrossemi*, *Ceophloeus lineatus obsoletus*, *Empidonax difficilis culiacani*, *Empidonax albigularis subtilis*, *Thryothorus felix sonorae*, *Toxostoma curvirostre maculatum*. *Turdus rufo-palliatus grisior*, *Polioptila nigriceps restricta*, *Vireo pallens paluster* (one record from Senora), *Carpodacus mexicanus rhodopnus*, *Aimophila carpalis bangsi* (breeds).

11. **Nayarit-Guerrero Biotic Province.**—The Nayarit-Guerrero Biotic Province occupies the coastal region within the Arid Tropical Zone from southern Sinaloa, south through Nayarit, western Jalisco, Colima, southwestern Michoacan, and southern Guerrero. It also includes the bottom of the valley of the Río Balsas in southern Michoacan and northern Guerrero, and the Islas Tres Marias off the coast of Nayarit, which form a well-marked biotic district. Irregular rolling plains with interspersed low ridges make up the mainland surface. Within this tropical area the year is divided into a wet and a dry season. Frequent and abundant rains begin in May or June and end in November or December. The arid general character is due to the length of the rainless season from December to May when most of the vegetation becomes leafless, except where there are underground water supplies.

Belts of more or less closed forest, especially on north slopes of hills and along stream valleys, alternate with savanna areas. Many of the dominant plants of this province are of wide distribution, but are associated with mammals and birds of more limited geographic range.

Among the prominent plants are several species of wild figs (*Ficus*) and of *Elaphrium*, *Cedrela occidentalis*, *Ceiba parvifolia*, *Haematoxylum brasiletto*, *Erythrina occidentalis*, *Ipomoea wolcottiana*, *Randia blepharophylla*, *Acacia hindsii*, *Mimosa colimensis*, and many others.

Among the mammals are: *Noctilio leporinus mexicanus*, *Potos flavus guerrerensis*, *Nasua narica molaris*, *Felis pardalis nelsoni*, *Citellus annulatus annulatus*, *Citellus adocetus*, *Platygeomys fumosus*, *Pappogeomys bulleri nayaritensis*, *Orthogeomys grandis guerrerensis*, *Hodomys alleni alleni*, *Xenomys nelsoni*, and *Pecari angulatus humeralis*.

Some of the bird forms apparently confined to the mainland of this province are *Lophortyx douglasii impedita*, *Cissilopha san-blasiana nelsoni*, *Habia rubica rosea*. By far the largest number of forms confined to the province appear in the Tres Marias Islands biotic district, of which some are *Buteo jamaicensis fumosus*, *Polyborus cheriway pallidus*, *Rallus longirostris nayaritensis*, *Forpus cyanopygius insularis*, *Amazona ochrocephala tresmariae*, *Nyctidromus albicollis insularis*, *Cynanthus latirostris lawrencei*, *Dendrocopos scalaris graysoni*, *Platypsaris aglaiae insularis*, *Thryothorus felix lawrencii*, *Melanotis caerulescens*

longirostris, Turdus rufo-palliatus graysoni, Myadestes obscurus insularis, Vireo virescens forreri, Granatellus venustus francescae, Icterus pustulatus graysonii, Piranga bidentata flammea, Richmondena cardinalis mariae, Aimophila humeralis asticta.

12. **Sierra Madre Oriental Biotic Province.**—The Sierra Madre Oriental Biotic Province is named for the outstanding feature, the northern section of the Sierra Madre Oriental, which forms a general range in southeastern Coahuila, southern Nuevo León, southwestern Tamaulipas, and eastern San Luis Potosí. Some of the higher mountains are disposed in irregular groups that rise abruptly from the plains to more than 9,000 feet. One prominent peak, the Cerro Potosí, in western Nuevo León reaches to more than 12,000 feet.

The province occupies an intermediate position and is allied to neighboring provinces on all sides. The Sierra Madre Oriental receives a moderate amount of rainfall from moisture-laden winds from over the Gulf, but is much drier than the mountains of Veracruz. Occasional winter storms leave some snow for a short time on the upper slopes of the mountains. The plains at the lower levels lie in the Lower Austral Zone but slope up into Upper Austral Zone, both zones reaching to relatively high elevations due to the high base level. The plains along the basal slopes of the mountains consist in part of open grasslands, interspersed with thickets of thorny shrubs and small trees, including *Prosopis juliflora*, acacias of various kinds, yuccas, agaves, and cacti. Oaks, nut pines (*Pinus cembroides* and *P. nelsoni*) and manzanita (*Arctostaphylos pungens*) on the middle slopes of the mountains are indicators of the Upper Austral Zone. Higher on the slopes are limited stands of *Pinus leiophylla* and madroño (*Arbutus*), assigned to the Transition Zone, and near the higher summits a few firs (*Abies religiosa*), pines (*Pinus flexilis*), and aspens (*Populus tremuloides*) occur as Canadian Zone elements.

Among the mammals of the province are *Corynorhinus phyllotis, Idionycteris mexicanus, Euarctos americanus eremicus, Conepatus pediculus, Microtus mexicanus subsimus*, and *Odocoileus virginianus miquihuanensis*.

Among the birds confined to this province are *Colinus virginianus aridus, Dendrocopos villosus intermedius*.

13. **Transverse Volcanic Biotic Province.**—The dominant geographic position of the Transverse Volcanic Biotic Province has already been pointed out. It occupies a transverse volcanic area extending across the southern and highest part of the interior plateau. The new volcano, Paricutín, that began to rise suddenly from the level of a cornfield in Michoacan, in February 1942, is the latest manifestation of a mountain-building process that has been in progress here and there for ages within the restricted region. Parts of 11 states may conveniently be included, but the heart of the province is a belt about 400 miles in length and some 60 miles in width. As indicated by Merriam (North American Fauna no. 8, p. 30, 1895), in discussing the remarkable distribution of the pocket gophers of the region, this belt contains 13 of the highest peaks of Mexico, all of which attain an altitude of 12,000 feet or more. Three of these rise to more than 17,000 feet and are capped by small areas representing the Arctic Zone. The only 12,000-foot peaks that stand outside the limits of the belt are Cerro Potosí in Nuevo León and Cerro Zempoaltepec in Oaxaca, the latter regarded by us as a southeastern outpost of the province. In this area of titanic sculpture, all of the life zones of North America are represented and the full play of natural forces has favored the evolution or survival of a remarkable number of genera, species, and regional races that find congenial habitats often in close proximity but under widely varying local environmental conditions. Receding glaciers on Cerro Ixtaccihuatl and the glacier-eroded top of the Cofre de Perote, Veracruz, are evidence that the area has been colder than at present. Fossil remains of the mastodon, mammoth, and other extinct animals of Pleistocene time indicate that the high valleys of Mexico and Toluca once supported a more luxuriant growth of vegetation than at the present time. Rains and snow are frequent during the summer in the mountains, but the winters are dry and on the interior plateau arid general conditions prevail. Along the eastern slope of the mountains forming the eastern border of the province prevailing winds from over the Gulf discharge their moisture in a heavily forested section, probably the wettest in Mexico. In addition to the regular summer rainy season, when heavy showers are of

almost daily occurrence, periodical winter storms known as "nortes" or "northers", bring steady, drizzling rains that usually continue for three days or longer at a time. Fog, often having the effect of light rain, enshrouds the slopes between 5,000 and 7,000 feet altitude nearly throughout the year. This cloud forest belt forms a section of the Humid Upper Tropical Zone, which, owing to its coolness, partakes of the biotic character of the upper slopes of the mountains, a condition that has probably endured as a result of changing climate during Pleistocene time. Along the lower eastern slopes of the mountains the cloud forest belt passes gradually into the tropical lowlands of the Veracruz Biotic Province. Toward the north the transition is mainly into the Sierra Madre Oriental Biotic Province, which, north of the valley of the Río Panuco, also embraces high mountains.

Owing to the wide range in altitude and climatic conditions, the vegetation of the different areas within the province is extremely varied. The cloud forest mentioned contains many oaks, but includes three ferns and many other divergent components. The high interior plains are made up largely of grasslands, intermixed with patches of small trees, shrubs, yuccas, agaves, and cacti. On the slopes of the mountains are belts of oaks and pines, giving way to firs at about 9,000 feet, and these in turn to other pines and alders, forming a timberline zone on the highest mountains. The longest river system (the Lerma) wholly within Mexico crosses from east to west along two-thirds of the northern half of the province and with the marshes and the largest lakes of Mexico creates a biotic district within the province.

Some genera and a number of species of mammals are restricted to the Transverse Volcanic Biotic Province. Among the species, to mention only a few, are *Notiosorex gigas*, *Cryptotis magna*, *Romerolagus diazi*, *Cratogeomys merriami*, *Zygogeomys trichopus*, *Platygeomys gymnurus*, *Heterogeomys lanius*, *Neotomodon alstoni*, *Nelsonia goldmani*, and *Pitymys quasiater*.

Of all the provinces this one has the largest number of bird forms which are confined to it, numbering at least 80. Of these 8 are full species, and one is a genus. Lack of space permits the mention of only the following characteristic forms: *Dendrortyx barbatus*, *Dendrortyx macroura macroura*, *Dendrortyx m. oaxacae*, *Colinus virginianus nigripectus*, *Meleagris gallopavo gallopavo*, *Rallus longirostris tenuirostris*, *Coturnicops noveboracensis goldmani*, *Geococcyx velox velox*, *Otus asio sortilegus*, *Cynanthus latirostris propinquus*, *Thalurania furcata ridgwayi*, *Lampornis amethystinus amethystinus*, *Xiphocolaptes promeropirhynchus sclateri*, *Sittasomus griseicapillus jaliscensis*, *Empidonax difficilis immemoratus*, *Empidonax albigularis azillaris*, *Aechmolophus mexicanus*, *Eremophila alpestris chrysolaema*, *Cyanolyca nana*, *Aphelocoma coerulescens sumichrasti*, *Aphelocoma sordida sieberii*, *Certhia familiaris jaliscensis*, *Cistothorus platensis tinnulus*, *Heleodytes megalopterus megalopterus*, *Heleodytes jocosus gularis*, *Thryothorus felix grandis*, *Thryomanes bewickii bairdi*, *Henicorhina leucophrys mexicana*, *Catherpes mexicanus mexicanus*, *Toxostoma ocellatum*, *Toxostoma curvirostre curvirostre*, *Catharus occidentalis occidentalis*, *Sialia mexicana australis*, *Vireolanius melitophrys goldmani*, *Vireo nanus*, *Neochloe brevipennis*, *Dendroica aestiva dugesi*, *Geothlypis trichas melanops*, *Geothlypis chapalensis*, *Geothlypis speciosa*, *Geothlypis nelsoni nelsoni*, *Cassidix palustris*, *Carpodacus mexicanus centralis*, *Atlapetes torquatus virenticeps*, *Pipilo torquatus alticola*, *Pipilo fuscus fuscus*, *Pipilo fuscus toroi*, *Aimophila ruficauda acuminata*, *Melospiza melodia pectoralis*, *Melospiza melodia adusta*, *Toxostoma dorsale dumosum* (also in Chihuahua-Zacatecas Biotic Province).

14. **Veracruz Biotic Province.**—The Veracruz Biotic Province embraces the tropical lowlands from eastern San Luis Potosí, southern Tamaulipas, and northeastern Puebla, southeasterly through Veracruz and Tabasco and small portions of northern Oaxaca and Chiapas. It is dominated by tropical rain forest, but arid sections, especially near the coast in Veracruz are included in its scope. The tropical evergreen rain forest resulting from a combination of high temperature, abundant moisture, and fertile soil, represents the optimum type of vegetative vigor and luxuriance. The climax areas in this type contain the largest trees, and rapid growth characterizes plant species of infinite number and form. Much of the original forest cover has been removed or logged over by man, however, and the

areas that remain are those least accessible along the lower basal slopes of the mountains. Nearer the coast the rainfall is much less and there are lengthy dry periods during which many trees lose their leaves. Among the trees only a few can be mentioned here. These include the wild figs of various species, *Castilla elastica*, *Cecropia mexicana*, *Elaphrium pannosum*, *Swietenia macrophylla*, *Cedrela mexicana*, *Pachira aquatica*, *Theobroma cacao*, and *Calocarpum mammosum*. Associated with the flora is a dependent avifauna of extraordinary richness and variety. Many of the mammals are characteristic and mark northern extensions of the ranges of tropical species of wide distribution. In the tropical rain forest, however, with its coarse vegetation and heavy canopy, conditions are less favorable for mammals and fewer species are present than in more open areas where the admission of more light produces denser ground cover and more food. A number of the mammals are arboreal.

A few characteristic mammals are: *Nasua narica narica*, *Potos flavus aztecus*, *Bassariscus sumichrasti sumichrasti*, *Tayra barbara senex*, *Felis onca veraecrucis*, *Alouatta palliata mexicana*, *Ateles geoffroyi vellerosus*, *Mazama sartorii sartorii*, and *Tamandua tetradactyla mexicana*.

Some of the birds apparently confined to this province are *Tinamus major percautus*, *Crypturellus soui meserythrus*, *Rostrhamus sociabilis major*, *Paphoisa helenae*, *Colinus virginianus godmani*, *Heliornis fulica*, *Pionopsitta haematotis*, *Amazona farinosa guatemalae*, *Otus guatemalae fuscus*, *Lophostrix cristata stricklandi*, *Campylopterus curvipennis excellens*, *Leptopogon amaurocephalus pileatus*, *Myioborus miniatus molochinus*, *Habia rubica holobrunnea*, *Richmondena cardinalis coccinea*, *Cyanocompsa cyanoides concreta*, *Sporophila aurita corvina*, *Sicalis luteola chrysops*, *Arremonops rufivirgatus crassirostris*, *Grallaria guatimalensis guatimalensis*, *Galbula melanogenia*.

15. **Sierra Madre del Sur Biotic Province.**—The Sierra Madre del Sur Biotic Province embraces high mountain areas extending from west to east through central Guerrero and the mountains and interior valleys of central and western Oaxaca. It is allied to the Transverse Volcanic Biotic Province, with which it is closely connected in northern Oaxaca. The higher mountains rise to more than 10,000 feet altitude. The northern and southern slopes in Guerrero and the interior valleys of Oaxaca dip down into the Arid Tropical Zone. The middle slopes of the mountains near the Pacific coast lend variety by bearing patches of Humid Upper Tropical Zone, marked by the presence of tree ferns and other moisture-loving plants associated with mammals and birds of restricted distribution. The climate is similar to that of the plateau to the north. The summer rains are copious and the winters are dry.

Belts of oaks, pines and firs clothe the upper slopes of the high mountains. The interior valley of Oaxaca is a nearly level plain with trees or bushes irregularly distributed over its surface. Among the trees on the plain are the mezquite (*Prosopis juliflora*), several species of *Acacia*, *Cassia*, and tree *Ipomoea*, and along streams grow thickets of *Baccharis* bushes and scattered bald cypress trees (*Taxodium mucronatum*). A bald cypress at Mitla in the Valley of Oaxaca, with a trunk circumference of 51.8 meters, is believed to be the largest tree in Mexico. A few cacti, yuccas, and agaves also occur.

Among the mammals are *Sorex saussurei oaxacae*, *Sciurus poliopus effugius*, *Orthogeomys grandis felipensis*, *Liomys annectens*, *Liomys guerrerensis*, *Oryzomys guerrerensis*, *Microtus fulviventer*, *Sylvilagus insonus*, and *Odocoileus virginianus oaxacensis*.

Among the forms of bird-life apparently confined to this province are *Colinus virginianus atriceps*, *Phaethornis superciliosus mexicanus*, *Lampornis amethystinus margaritae*, *Aulacorhynchus wagleri*, *Xiphocolaptes promeropirhynchus omiltemensis*, *Xiphorhynchus flavigaster megarhynchus*, *Automolus rubiginosus guerrerensis*, *Thryothorus sinaloa russeus*, *Turdus migratorius permixtus*, *Ptilogonys cinereus pallescens*, *Chlorospingus opthalmicus albifrons*, *Carpodacus mexicanus griscomi*, *Amaurospizopsis relictus*, *Aimophila rufescens subvespera*.

16. **Tehuantepec Biotic Province.**—The Tehuantepec Biotic Province occupies the arid Pacific coastal strip of Oaxaca, the southern side of the Isthmus of Tehuantepec, and is continued southeastward along the coast of the State of Chiapas to beyond the Guatemalan border. It also includes the arid area extending eastward from the Isthmus along the valley

of the Río Grande de Chiapas, in the interior of the state of the same name. In marked contrast, the province thus interdigitates with the Chiapas Highlands Biotic Province. It is allied to the Nayarit-Guerrero Biotic Province toward the west, which is very similar in climate and character of land surface, but differs notably in biotic composition. Farther northwest the province abuts on the eastern end of the Sierra Madre del Sur Biotic Province, with which it has little in common. Across the Isthmus of Tehuantepec there is a tropical connection with the Veracruz Biotic Province, which differs widely in climate and combination of species contained.

Open, nearly level, savanna areas occur near the Pacific coast, but the land surface in general is undulating or hilly and covered with a rather thin growth of tropical shrubs and trees 20 to 30 feet in height. Stiff thorny bushes abound and often form thickets difficult to penetrate. The many trees include the mezquite (*Prosopis juliflora*), several species of *Acacia*, *Pithecollobium*, *Ipomoea*, *Annona*, and others of wide distribution. As elsewhere some of the largest trees are wild figs (*Ficus*), which tower above the general top of the low forest.

Among the mammals are *Spilogale angustifrons tropicalis*, *Sciurus socialis socialis*, *Orthogeomys grandis scalops*, *Heterogeomys hispidus tehuantepecus*, *Liomys crispus crispus*, *Tylomys bullaris*, *Neotoma feruginea isthmica*, *Dasyprocta punctata chiapensis*, *Lepus flavigularis*, and *Pecari angulatus nelsoni*.

Because of the paucity of our data on this province, where it interdigitates with the next province, it is difficult to determine the proper allocation of the bird forms for either province, which in some cases may be incorrect. Among the birds apparently confined to this province are *Tigrisoma lineatum lineatum*, *Buteo magnirostris petersi*, *Daptrius americanus guatemalensis*, *Ortalis vetula vallicola*, *Ortalis vetula leucogastra*, *Colinus virginianus insignis*, *Colinus virginianus salvini*, *Colinus virginianus coyolcos*, *Morococcyx erythropygus erythropygus*, *Compsothylpis pitiayumi inornata*, *Notharchus hyper-rhynchus dysoni*, *Centurus polygrammus frontalis*, *Centurus polygrammus polygrammus*, *Calocitta formosa azurea*, *Icterus pectoralis*, *pectoralis*, *Passerina rositae*, *Passerina leclancherii grandior*, *Aimophila ruficauda lawrencii*, *Aimophila sumichrasti*, *Arremonops rufivirgatus chiapensis*.

17. **Chiapas Highlands Biotic Province.**—The Chiapas Highlands Biotic Province marks the recurrence of a high mountain area east of the tropical gap at the Isthmus of Tehuantepec, obviously allied to but differing notably in biotic character from the mountains west of the Isthmian gap. Embraced in the province are the high mountains of northern Chiapas which extend southeastward into Guatemala, where, around the head of the valley of the Río Grande de Chiapas, they are connected with the range forming the continental backbone between this valley and the tropical lowlands of the Pacific coast of Chiapas. These elevated areas thus represent partially separated extensions into Chiapas of a high mountain mass of much greater height and magnitude in southern Guatemala. The northern unit consists of a broad irregular group of high mountains deeply cut by tropical canyons carrying drainage into the large rivers of Tabasco. The upper slopes of the mountains are covered with oaks and pines and a few firs (*Abies religiosa*) occur near the tops. Summer rains are heavy and fog is prevalent, especially along the middle northern slopes which are Humid Upper Tropical in zonal position. The southern unit is restricted mainly to the narrow mountain ridge overlooking the coastal strip and facing the Pacific Ocean. Near the Guatemalan border high mountains extending into Guatemala bear firs near the tops. Farther west they are pine-covered but of lesser elevation. Humid Tropical areas on the slopes have been found suitable for coffee culture. As elsewhere along the Pacific front of the mountains, the humid areas are less extremely wet than on the Gulf side where fog is more prevalent and some precipitation may occur during the dry season for the region as a whole.

Among the mammals are *Sorex saussurei cristobalensis*, *Sciurus griseoflavus chiapensis*, *Glaucomys volans goldmani*, *Heterogeomys hispidus chiapensis*, *Heteromys desmarestianus desmarestianus*, *Heteromys nelsoni*, *Tylomys tumbalensis*, *Scotinomys teguina subnubilus*, and *Odocoileus virginianus nelsoni*.

Among the forms of bird-life, which are apparently confined to this province, are the following: *Penelopina nigra nigra, Colinus virginianus minor, Dactylortyx thoracicus lineolatus, Dactylortyx thoracicus chiapensis, Caprimulgus vociferus chiapensis, Chaetura nubicola, Xiphocolaptes promeropirhynchus emigrans, Aphelocoma unicolor coelestis, Thryothorus rufalbus rufalbus, Troglodytes rufociliatus rufociliatus, Turdus ignobilis differens, Catharus occidentalis alticola, Peucedramus olivaceus aurantiacus, Ergaticus versicolor, Atlapetes gutturalis griseipectus, Junco phaeonotus fulvescens.*

18. **Yucatán Peninsula Biotic Province.**—The Yucatán Peninsula Biotic Province is formed by the low, flat peninsular area that projects far out toward the island of Cuba from the mainland between the Gulf of Mexico and the Caribbean Sea. The state of Yucatán, nearly all of Campeche, Quintana Roo, Cozumel Island, northern Guatemala, and northern British Honduras, are included within its scope. In all this vast territory there are no mountains worthy of the name, and scarcely a hill more than 300 to 500 feet high. A comparatively thin layer of soil covers the underlying limestone which is porous and absorbs moisture so readily that there is little surface stream drainage. Numerous natural sinkholes in the rock, varying from a few feet to more than 100 yards across, contain water of considerable depth at less than 100 feet below the surface of the ground. A few small depressions contain shallow water, the largest and most notable being Lake Peten in northern Guatemala.

The year is divided into two seasons, the rainy season from June to about the end of November, and the dry season from December to June. During the rainy season torrential showers fall mainly in the afternoon. During the dry period occasional showers and some fog maintain moist conditions and an evergreen forest, owing to prevailing winds along the Caribbean coast and throughout the southern part of the peninsula. In Yucatan, however, the dry season is more pronounced and a low, but dense, arid tropical forest becomes nearly leafless. Palms tend to predominate in the heavy forest along the Caribbean coast. The province is, therefore, subdivisible into arid and moderately humid sections representing biotic districts, with some species dividing into subspecies peculiar to each. Cozumel Island is in itself an important distribution center with various well-marked species peculiar to it, and should be recognized as a biotic district. In general uniformity, however, the province as a whole exhibits a marked departure from the mountainous country forming the continental backbone to the southward.

Among the plants are: *Beaucarnia pliabilis, Agave sisalana, Acacia globulifera, Lysiloma sabicu, Enterolobium cyclocarpum, Haematoxylum campechianum, Caesalpinia gaumeri, Esenbeckia fagara, Elaphrium pubescens,* and *Pachycereus gaumeri.*

Among the mammals of the Yucatán Peninsula are: *Didelphis marsupialis yucatanensis, Nasua narica yucatanica, Felis onca goldmani, Ateles geoffroyi yucatanensis, Sciurus deppei vivax, Sciurus yucatanensis yucatanensis, Sciurus yucatanensis baliolus, Heterogeomys hispidus yucatanensis, Heteromys gaumeri, Dasyprocta punctata yucatanica, Pecari angulatus yucatanensis, Odocoileus virginianus yucatanensis,* and *Mazama sartorii pandora.* Some mammals of Cozumel Island are *Procyon pygmaeus, Nasua nelsoni, Oryzomys cozumelae.*

This province is very rich in bird-life and has the second largest number of forms confined to it of all the provinces. Some of these are *Crypturellus cinnamomeus intermedius, Colymbus dominicus dominicus, Phoenicopterus ruber, Buteo magnirostris gracilis, Crax rubra griscomi, Ortalis vetula pallidiventris, Colinus nigrogularis caboti, Dactylortyx thoracicus sharpei, Agriocharis ocellata, Rallus longirostris pallidus, Amazona xantholora, Chlorostilbon canivetii forficatus, Pteroglossus torquatus erythrozonus, Centurus rubriventris pygmaeus, Dendrocopos scalaris parvus, Dendrocincla anabatina typhla, Thamnophilus doliatus yucatanensis, Attila spadiceus gaumeri, Attila spadiceus cozumelae, Tityra semifasciata deses, Troglodytes musculus beani, Nannorchilus leucogaster brachyurus, Toxostoma guttatum, Mimus gilvus leucophaeus, Cyclarhis gujanensis yucatanensis, Coereba flaveola caboti, Dendroica petechia rufivertex, Granatellus sallaei boucardi, Icterus auratus, Icterus cucullatus igneus, Icterus cucullatus cozumelae, Spindalis zena benedicti, Habia rubica nelsoni, Habia gutturalis rooensis, Habia gutturalis insularis, Richmondena cardinalis yucatanica, Richmondena cardinalis saturata.*

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SOME ASPECTS OF THE LIFE HISTORY AND ECOLOGY OF THE OPOSSUM IN CENTRAL MISSOURI[1]

By Harold C. Reynolds

Although the opossum (*Didelphis virginiana* Kerr) is one of the only two native species of North American marsupials living north of the Rio Grande and a common furbearing mammal in most of the eastern half of the United States, our knowledge of its life history and ecology is still in a somewhat fragmentary and disconnected state For more than a century this opossum has been intensively studied in the laboratory, but it was not until 1942, when Lay published the results of his studies in Jefferson County, Texas, that the first general consideration of the life history and ecology of the species came into print. Except for an earlier study of the breeding season in Texas (Hartman, 1928), the analysis of the scats and stomachs of 40 opossums collected in Michigan (Dearborn, 1932), and an investigation of the winter dens of 36 individuals in Mississippi (Yeager, 1936), previous information regarding the habits of the animal in the wild consisted largely of notes based upon limited observations. Probably the opossum's low pelt value, its present and past abundance, and its secretive, nocturnal habits account for the neglect of the species as a subject of field research.

The present study of the Virginia opossum (*Didelphis v. virginiana* Kerr), the subspecies occurring in central Missouri, was conducted during a period of 16½ months, from February 1, 1941, to June 15, 1942. During this period 143 adult or subadult individuals were examined. Although a few specimens were obtained from neighboring counties, the field work was restricted to the area within 20 miles of the city of Columbia in Boone County. Work during the summer months was irregular; thus there are few data for the period June to September.

The study was conducted under a research fellowship provided by the Edward K. Love Conservation Foundation at the University of Missouri. It was directed by Mr. Douglas E. Wade, Instructor in Zoology, University of Missouri, with assistance from Dr. Rudolf Bennitt, Professor of Zoology, University of Missouri, and Dr. Paul D. Dalke, Biologist, U. S. Fish and Wildlife Service, to each of whom the writer wishes to express his appreciation. Thanks are also due the following: Dr. Edward McCrady, Jr., Professor of Biology, University of the South; Dr. Adrian J. Durant, Professor of Veterinary Science, University of Missouri; Dr. Waldo H. Furgason, Assistant Professor of Zoology, University of Missouri; Dr. Raymond W. Wilhelmi, Instructor in Zoology, University of Missouri; Dr. H. E. Ewing, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture; Mr. Harry E. Brown, Instructor in Entomology, University of Missouri; Miss Clara Fuhr, Assistant Botanist, U. S. Department of Agriculture, Seed Testing Laboratory; Mr. Wayne Murray

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and Mr. Robert Roselle, graduate students, University of Missouri; Mr. Stanton Hudson, undergraduate student, University of Missouri; Mr. Wesley Shaw of Columbia; and the fur buyers in Columbia and vicinity.

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GENERAL METHODS

Unlike the procedure used in most earlier life-history investigations of nocturnal mammals, more than 80 percent (116) of the animals examined were obtained alive by hunting at night with dogs. Live-trapping was conducted on a small scale during the early part of the study, but was discontinued in favor of the more successful method of collecting with dogs.

No particular study areas were established. Instead, as many and as diverse areas as possible were hunted, in order that the data obtained would be a fair indication of the opossum's habitat-preferences.

Each captured opossum, before being released, was marked in two ways: (1) through the ear by means of a numbered clip (Number 1005, Size 3, National Band and Tag Company); and (2) by toe-clipping, which involved amputation of that portion of the toe beyond the distal joint. In no case were the tips of more than two toes removed from a foot. Since only a few of the marked and released animals were recovered, it cannot be stated which method proved the more satisfactory; observation of captives showed that affixing the ear-tag was often followed by local infection and sloughing off of a portion of the ear. This, together with freezing of the ears during cold weather, occasionally resulted in the loss of the tags. On the other hand, the toes that were cut healed quickly and without apparent complications.

BREEDING HABITS

Forty females were carrying young in the pouch at the time they were obtained; two were pregnant and gave birth a few days after having been brought to the laboratory. The two females having litters of known age and nine others captured while their young were less than 15 days old were kept in captivity in order to study the growth rate of the young. Upon the basis of the weights and measurements of the young at various ages, combined with those given by Moore and Bodian (1940), it was possible to estimate the ages of other litters taken in the wild to within 3 days for litters less than 24 days old, to within 4 days for those 24 to 48 days old, and to within 5 days for those 49 to 65 days old. Thus the probable extent of the breeding season could be learned. Age estimation made by Dr. Edward McCrady, Jr., of a preserved young individual from each of 17 litters in no case varied more than 4 days from that made by the present investigator.

The 1941 and 1942 breeding seasons of the opossum in central Missouri began about the first of February. Michel (1850) indicated that in South Carolina

the breeding season begins in December Hartman (1928) and Lay (1942) agreed that the breeding season in Texas begins about the first of January. Thus it appears that the onset of the season occurs in Missouri at least one month later than in these more southern states.

As shown in Table 1, the earliest birth among the litters examined was that from a female captured while pregnant; it occurred during the night of February 12–13, 1942, 11 days after she had been brought to the laboratory. Since the length of the gestation period of the opossum is between 12.5 and 13 days, according to the most recent investigators (Hartman, 1928; McCrady, 1938), this female was presumably mated on the last day of January. Judging from the estimated birth-dates, 27 percent of the females bearing young during the

TABLE 1.—*Estimated dates of birth of 42 litters of young taken during 1941 and 1942 in Boone County, Missouri*

DATE OF BIRTH	NO. OF LITTERS	DATE OF BIRTH	NO. OF LITTERS
*February 12	1	March 26	1
February 17	2	*March 28	1
February 18	1	March 30	1
February 19	1	April 2	2
February 20	2	May 16	1
February 21	3	May 19	1
February 22	1	May 21	1
February 23	2	May 24	2
February 24	1	May 25	1
February 26	1	May 26	1
February 27	2	May 29	1
February 28	4	June 1	2
March 3	1	June 3	1
March 16	1	June 4	1
March 18	2		

* Litters of known birth-date.

early part of the season had been mated during the first week of February, 45 percent during the second week, and 23 percent during the third week, indicating a mating "peak" during the second week of February in those years. Hartman (1923b) believed that in Texas the height of the mating season is reached during the third week in January.

Eight females were captured that had given birth between March 16 and April 2, from approximately six to nine weeks after the beginning of the breeding season. A natural explanation of this fact is that these individuals had failed to find mates during the first oestrus of the season and that after completing the regular dioestrous cycle of about 28 days (Hartman, 1923a) they had then mated and borne young. Two females taken during early April were without young; one of them at the time of capture was in the condition of pseudopregnancy described by Hartman (1921). Three females, captured in May, possessed enlarged mammary glands and elongated teats, indicating that young recently had been either weaned or lost.

Although none of the females that had been tagged and released was captured with a second litter, it is believed that the births occurring between May 16 and June 4 were second litters of the season. Since weaning usually occurs between the 80th and 90th days (McCrady, 1938), weaning of the second litters in central Missouri would be expected to occur by the latter part of August or the first few days in September. The fact that all of the 11 females captured during September were without young is further evidence that the second litters are weaned here by the early part of that month.

Thus, if we consider that the breeding season begins with the first matings and ends with the weaning of the last litters, this study shows that in central Missouri it extends approximately from the first of February to the first of September. Hartman (1928) indicated that the breeding season in Texas lasts until the end of September, whereas Lay (*op. cit.*) found no female with young later than July.

Since all of the females captured after September 1 were without young, there is no indication that a third litter is borne in central Missouri. Hartman (1928) thought it probable that a small percentage of unusually fecund females in Texas bear three litters; Lay (*op. cit.*) found no evidence of this. At least two weeks must elapse between the weaning of the first litter and the birth of the second for the following reasons: (1) "Lactation usually inhibits the recurrence of oestrus" (Hartman, 1923a), although "there are several records of lactating females almost at the stage of oestrus" (Hartman, 1923b), and McCrady (1938) has seen a female copulate on the second day after she was separated from her litter, producing a new litter 13 days later. (2) "One must, furthermore, allow several weeks for the greatly enlarged teats to retrogress before the birth of a new litter; for it is manifestly impossible for newly-born young to attach themselves to any but very small nipples" (Hartman, 1923b). This means that if the earliest litters in central Missouri are produced during the middle of February, as was revealed by the study, the second litters could be weaned during the latter part of the first week in August but not before that time. Consequently, it would be impossible for even the earliest-breeding females to rear third litters in this portion of the state before the advent of cold weather. During June, 5 of 13 females obtained were without young; this may be evidence that some females do not produce even a second litter in central Missouri, since no female was found to produce young later than June 4. On the contrary, Lay (*op. cit.*) found that "in no instance [in Texas] did the records reveal that a female carried less than two litters during the breeding season."

Forty-two litters examined averaged 8.9 young per litter (*cf.* Table 2). One-third of the litters contained 8 young each; the smallest contained 5 and the largest 13. Lay (*op. cit.*) reported the much lower average of 6.8 young in 65 litters examined in Texas.

SEX RATIO

The sex ratio among the 116 opossums collected through the use of dogs and 4 that were live-trapped was 55 percent males to 45 percent females. The other

23 individuals studied were not included in calculating this ratio, since they were collected by persons who made special efforts to bring in females, particularly those with young.

During the open hunting season (December 1941 and January 1942) 1,312 opossum pelts that had been sold to fur dealers in the vicinity of Columbia were examined for added information concerning the sex ratio. In 1,076 of these, the presence of portions of the pouch or testes made it possible to ascertain the sex of the animal. Of this number, 620 were males and 456 were females, a ratio of 58 percent males to 42 percent females. This ratio agrees closely with that (57♂:43♀) recorded by Bennitt and Nagel (1937) from 2,185 animals

TABLE 2.—*Numbers of young in 42 litters of opossums taken during 1941 and 1942 in Boone County, Missouri*

NO. OF POUCH-YOUNG	NO. OF LITTERS
5	1
6	2
7	3
8	14
9	8
10	7
11	4
12	2
13	1
Average..... 8.9	

killed in Missouri, and with the same ratio found by Lay (*op. cit.*) among 117 animals trapped in Texas.

FOOD HABITS

In most publications, references to the opossum's food have been very general, being either statements concerning the classes of food taken, lists of items that opossums have been known to eat, or notes on some particular food that an individual ate. Actual scat or stomach analyses have been made only by Dearborn (*op. cit.*) and Lay (*op. cit.*), but even these were conducted during limited periods and took into account only the classes of food without identifying the special items found.

Dearborn (*op. cit.*) made a volumetric analysis of the contents of 23 opossum stomachs taken in November, 1 stomach taken in March, the scats from 14 opossums taken in July, and the scats from 2 opossums taken in August. He stated that, by volume, fruits constituted 30.42%; birds, 24.71%; mammals, 23.17%; insects, 16.67%; crayfish, 3.52%; snails, 0.66%; snakes, 0.46%; frogs, 0.33%; and hens' eggs 0.06%. His findings, however, are difficult to interpret for two reasons: (1) He apparently determined volumetric ratios of the remains of food elements in the scats of 16 opossums and combined the results with the

TABLE 3.—*Percentage frequency of occurrence of food items in 259 scats of opossums taken during the nine months of September 1941 to May 1942, inclusive, Boone County, Missouri*

FOOD ITEM	FALL (100 SCATS)	WINTER (59 SCATS)	SPRING (100 SCATS)	TOTAL (259 SCATS)
INSECTS				
Orthoptera				
Long-horned Grasshoppers (Tettigoniidae)	10	0	0	3.9
Crickets (Gryllidae)	7	22	16	13.9
Short-horned Grasshoppers (Locustidae)	50	25	34	38.2
Cockroaches (Blattidae)	5	7	9	6.9
Hemiptera				
Assassin Bugs (Reduviidae)	0	2	0	0.4
Squash Bugs (Coreidae)	15	34	14	18.9
Stink Bugs (Pentatomidae)	10	39	14	18.1
Coleoptera				
Ground Beetles (Carabidae)	52	32	57	49.4
Tiger Beetles (Cicindelidae)	2	0	7	3.5
Water-Scavenger Beetles (Hydrophilidae)	1	0	0	0.4
Carrion Beetles (Silphidae)	0	0	1	0.4
Soldier Beetles, larvae (Cantharidae)	0	5	2	1.9
Darkling Beetles (Tenebrionidae)	1	0	0	0.4
Lamellicorn Beetles (Scarabaeidae)	35	27	62	43.6
Stag Beetles (Lucanidae)	7	0	1	3.1
Passalid Beetles (Passalidae)	7	0	0	2.7
Leaf Beetles (Chrysomelidae)	0	0	1	0.4
Unidentified larvae	1	0	0	0.4
Lepidoptera				
Owlet Moths (Noctuidae)	0	2	17	6.9
Unidentified pupae	1	0	1	0.8
Diptera				
Flesh Flies (Sarcophagidae)	1	0	5	2.3
Unidentified larvae	1	0	4	1.9
Hymenoptera				
Ants (Formicidae)	4	3	2	3.1
Wasps (Vespidae)	1	0	5	2.3
Unidentified adults	0	0	2	0.8
Total				87.6
FRUITS				
Red Mulberry (*Morus rubra*)	0	0	1	0.4
Pokeberry (*Phytolacca decandra*)	48	7	5	22.0
Green Brier (*Smilax* sp.)	0	15	3	4.6
Hackberry (*Celtis occidentalis*)	0	10	4	3.9
Ground Cherry (*Physalis* sp.)	15	10	9	11.6
Persimmon (*Diospyros virginiana*)	16	5	0	7.3
Grape (*Vitis* sp.)	23	12	0	11.6
Blackberry (*Rubus* sp.)	15	0	0	5.8
Total				50.6

TABLE 3.—*Continued*

FOOD ITEM	FALL (100 SCATS)	WINTER (59 SCATS)	SPRING (100 SCATS)	TOTAL (259 SCATS)
INVERTEBRATES (other than insects)				
Arthropoda				
Millipedes (Diplopoda)	0	7	4	3.1
Crayfish (*Cambarus* sp.)	3	2	8	4.6
Sow bug (*Oniscus asellus*)	2	2	1	1.5
Mollusca				
Land Snails (*Polygyra* spp.)	39	17	26	29.0
Fresh-water Snail (*Physa* sp.)	1	0	1	0.8
Slug (*Limax* sp.)	0	0	1	0.4
Total				32.4
MAMMALS				
Cottontail (*Sylvilagus floridanus*)	6	20	11	11.2
Mole (*Scalopus aquaticus*)	2	10	7	5.8
Opossum (*Didelphis virginiana*)	0	3	2	1.5
House Cat (*Felis libyca domestica*)	1	0	1	0.8
Fox Squirrel (*Sciurus niger rufiventer*)	2	5	0	1.9
Meadow Mouse (*Microtus* sp.)	0	2	3	1.5
Unidentified hair	5	12	4	6.2
Total				28.2
REPTILES				
Sauria				
Blue-tailed Skink (*Eumeces fasciatus*)	2	0	10	4.6
Fence Lizard (*Sceloporus undulatus*)	0	0	10	3.9
Serpentes				
Worm Snake (*Carphophis amoena vermis*)	0	0	10	3.9
Ring-necked Snake (*Diadophis punctatus*)	0	0	7	2.7
Unidentified scales	4	2	6	4.2
Total				18.9
CULTIVATED GRAINS AND MISCELLANEOUS SEEDS				
Corn (*Zea mays*)	2	17	9	8.1
Winter Wheat (*Triticum aestivum*)	0	3	0	0.8
Sorghum (*Holcus sorghum*)	1	0	0	0.4
Pigweed (*Amaranthus retroflexus*)	1	0	1	0.8
Fall Panic Grass (*Panicum dichotomiflorum*)	0	0	2	0.8
Meadow Grass (*Poa* sp.)	1	0	0	0.4
Timothy (*Phleum pratense*)	1	0	0	0.4
Alfalfa (*Medicago sativa*)	1	0	0	0.4
Bent Grass (*Agrostis* sp.)	0	2	0	0.4
Clover (*Trifolium* sp.)	1	0	0	0.4
Sweet Clover (*Melilotus* sp.)	1	0	0	0.4
Korean Lespedeza (*Lespedeza stipulacea*)	1	0	0	0.4
Foxtail (*Setaria* sp.)	0	2	0	0·4
Unidentified seeds	1	0	1	0.8
Total				12.7

TABLE 3.—*Concluded*

FOOD ITEM	FALL (100 SCATS)	WINTER (59 SCATS)	SPRING (100 SCATS)	TOTAL (259 SCATS)
BIRDS AND EGGS				
Domestic Chicken (*Gallus gallus*)	3	5	4	3.9
Domestic Chicken, eggs	0	2	1	0.8
Crow (*Corvus brachyrhynchos*)	1	0	0	0.4
Unidentified feathers	2	7	4	3.9
Total				8.9

volumetric ratios of elements in 24 stomachs; and (2) he stated: "Two-thirds of the bird remains were from poultry refuse discarded in preparations for Thanksgiving. More than two-thirds of the mammal remains consisted of opossum flesh, probably from animals which had been trapped and skinned."

Lay (*op. cit.*) examined the contents of 16 stomachs taken during September. He estimated that, by volume, the contents were: insects and worms, 45%; fruits, including French mulberry and grape, 11.8%; green leaves, 11%; trash (leaf and log litter), 10.6%; mammals, 7%; acorns, 4.7%; birds, 4.3%; crayfish, 3.3%; snails, 0.75%; grass seeds and cellophane, traces. Unfortunately Lay, like Dearborn, did not make a detailed classification of the food items.

The present investigation of food habits was based upon the analysis of the contents of 259 scats and 68 stomachs. The scats were collected during the period from September 1941 to May 1942, inclusive, and the stomachs during the period from December 1941 to May 1942, inclusive.

Early in the study, after a series of feeding experiments with captive specimens, it was found impossible to distinguish with any degree of certainty the scats of opossums from those of other mammals of comparable size. Consequently, the only scats analyzed were those obtained from animals captured in the wild and held in captivity until their digestive tracts were empty. Since several scats were often collected from one individual, those of approximately equal size were considered as units. This procedure was followed in order that the present findings may be compared with those from other food-habits studies in which the scats are collected in the field and each is treated as a unit. Only frequency of occurrence of the various food items was recorded for the scats, while in the case of the stomachs only volumetric measurements were made.

Table 3 gives the results of the scat analyses. The "fall" column includes the 100 scats collected during September, October, and November; the "winter" column includes the 59 scats collected during December, January, and February; and the "spring" column includes the 100 collected during March, April, and May. The last column of the table ("total") shows the percentage of frequency of occurrence for each item in the total (259 scats). Fewer scats were collected during the winter months, as this was the time when most of the stomachs were taken.

The methods employed in the volumetric measurements of the various food

items found in the stomachs were those used by Dixon (1925). Volume percentage of each item was obtained by spreading its material evenly in a flat pan marked off in squares, with ocular estimation of the percentage of the total area that each item occupied.

Of the 76 stomachs examined, 8 were empty except for the presence of opossum hair, leaving 68. Seventeen of these were taken in December, 21 in January, 5 in February, 7 in March, 8 in April, and 10 in May. The results of the volumetric analysis of the contents are shown in Table 4. Less than 0.1% was recorded as a "trace."

Insect remains occurred most frequently in the droppings and also in greatest volume in the stomachs. Among the 259 droppings, 227 contained the remains of insects of at least 25 different families. Thirteen or more of these families comprised 34.2 percent of the total volume of food in the stomachs. The reasons for the greater variety of insects in the scats are undoubtedly that more scats than stomachs were examined and that they were collected during a longer period. The families represented most frequently in the scats and in greatest volume in the stomachs were the ground beetles (Carabidae), lamellicorn beetles (Scarabaeidae), short-horned grasshoppers (Locustidae), squash bugs (Coreidae), and stink bugs (Pentatomidae). Crickets (Gryllidae) were found frequently but not in large numbers. Although a greater variety of insects was found in the fall and spring scats, only the Carabidae, Scarabaeidae, and Locustidae were outstanding in frequency during those seasons. However, each of six families (Carabidae, Scarabaeidae, Locustidae, Pentatomidae, Coreidae, and Gryllidae) was represented in 22 percent or more of the winter droppings.

It was even more surprising to find insect remains in the stomachs in larger amounts during the winter than during the spring, since in winter most insects are inactive and seemingly unavailable as food. Nevertheless, opossums find them, presumably in hibernation in hollow logs, holes, and other places. One stomach taken in January and another in February contained only Pentatomidae and Coreidae.

By volume, the most important single item of food taken by the 68 opossums whose stomachs were examined was the flesh of the cottontail rabbit (*Sylvilagus floridanus*). This fact and the presence of other mammal flesh in small quantities placed mammals, by volume, almost on a par with insects. In frequency of occurrence in all scats, mammals ranked fourth, but they ranked second in the scats collected (like the stomachs) during the winter and spring. At least 12 mammalian species were found, although the remains of only 6 were positively identified in the scats and of 10 in the stomachs. Mammals were of far greater importance in the diet of these opossums during the winter than in the fall or spring, rabbit remains alone having occurred in 20 percent of the droppings at that time. With the exception of the remains of moles (*Scalopus aquaticus*), found in 5.8 percent of all scat-examinations and in 10 percent of those made during the winter, no other species of mammal was identified in more than five scats. It is likely that the flesh of cottontails, house cats, opossums, squirrels, raccoons, and skunks was carrion. This view is supported by the known habits

TABLE 4.—*Results of volumetric analyses of sixty-eight opossum stomachs taken during the six months: December 1941 to May 1942, inclusive, Boone County, Missouri*

FOOD ITEM	PERCENT OF TOTAL VOLUME
INSECTS	
Orthoptera	
Crickets (Gryllidae)	0.7
Short-horned Grasshoppers (Locustidae)	4.4
Cockroaches (Blattidae)	trace
Hemiptera	
Assassin Bugs (Reduviidae)	trace
Squash Bugs (Coreidae)	4.8
Stink Bugs (Pentatomidae)	5.3
Coleoptera	
Ground Beetles (Carabidae)	8.7
Soldier Beetles, larvae (Cantharidae)	1.9
Lamellicorn Beetles (Scarabaeidae)	7.5
Lepidoptera	
Owlet Moths, larvae (Noctuidae)	0.3
Diptera	
Flesh Flies, larvae (Sarcophagidae)	trace
Hymenoptera	
Ants (Formicidae)	0.5
Unidentified adults	0.1
Total	34.2+
MAMMALS	
Opossum (*Didelphis virginiana*)	4.9
Mole (*Scalopus aquaticus*)	6.4
Raccoon (*Procyon lotor*)	1.0
Striped Skunk (*Mephitis mesomelas*)	trace
Fox Squirrel (*Sciurus niger*)	1.8
House Mouse (*Mus musculus*)	trace
White-footed Mouse (*Peromyscus* sp.)	0.7
Meadow Mouse (*Microtus* sp.)	1.6
Cottontail (*Sylvilagus floridanus*)	12.9
House Cat (*Felis libyca domestica*)	2.4
Unidentified flesh and hair	0.6
Total	32.3+
REPTILES	
Sauria	
Blue-tailed Skink (*Eumeces fasciatus*)	3.1
Fence Lizard (*Sceloporus undulatus*)	1.1
Serpentes	
Worm Snake (*Carphophis amoena vermis*)	2.5
Ring-necked Snake (*Diadophis punctatus arnyi*)	2.3
Unidentified scales	1.0
Total	10.0

TABLE 4.—*Concluded*

FOOD ITEM	PERCENT OF TOTAL VOLUME
CULTIVATED GRAINS AND MISCELLANEOUS SEEDS	
Corn (*Zea mays*)	7.3
Winter Wheat (*Triticum aestivum*)	trace
Bent Grass (*Agrostis* sp.)	trace
Unidentified seeds	trace
Total	7.3+
FRUITS	
Pokeberry (*Phytolacca decandra*)	1.5
Red Mulberry (*Morus rubra*)	1.7
Blackberry (*Rubus* sp.)	0.2
Grape (*Vitis* sp.)	0.2
Ground Cherry (*Physalis* sp.)	0.5
Hackberry (*Celtis occidentalis*)	1.2
Green Brier (*Smilax* sp.)	1.5
Total	6.8
BIRDS AND EGGS	
Domestic Chicken (*Gallus gallus*)	3.0
Domestic Chicken, eggs	0.2
Red-eyed Towhee (*Pipilo erythrophthalmus*)	1.7
Cardinal (*Richmondena cardinalis*)	trace
Unidentified (Fringillidae)	trace
Unidentified feathers	trace
Total	4.9+
INVERTEBRATES (other than insects)	
Arthropoda	
Millipedes (*Diplopoda*)	0.5
Crayfish (*Cambarus* sp.)	0.1
Mollusca	
Land Snails (*Polygyra* spp.)	3.9
Fresh-water Snail (*Physa* sp.)	trace
Slug (*Limax* sp.)	trace
Total	4.5+

of the opossum, by the improbability of its catching such agile prey alive, and also by the fact that five of the stomachs containing the flesh of these animals also contained one or more sarcophagid larvae. The death of rabbits wounded by hunters or predators probably contributes much to the opossum's diet in central Missouri.

Although the remains of fruits were found in 50.6 percent of the scats, they were seldom encountered during the late winter and spring. During the fall

and early winter, however, they probably formed a substantial portion of the diet of the animals. During the fall, pokeberries were consumed by far the most frequently; others of importance were wild grapes, persimmons, ground cherries, and blackberries. Although pokeberries and ground cherries were encountered occasionally in the scats throughout the winter and spring, while at the same time green brier and hackberry were found in 8 percent and 6 percent of the scats, respectively, these fruits were present in only minor quantities in the stomachs during those seasons. The red mulberry, however, was present in considerable quantities in two stomachs taken in May.

Land snails were taken frequently by the opossums throughout the period covered by this study. The volumetric analysis of the stomach-contents shows, however, that they were not present in large numbers and therefore are probably unimportant as a dietary item. Other invertebrates, except for insects, were found to be insignificant in both number and amount.

TABLE 5.—*Comparative summary of food habits study, showing relative importance of food classes*[1]

FREQUENCY OF OCCURRENCE	VOLUME
1. Insects	1. Insects
2. Fruits	2. Mammals
3. Invertebrates (other than insects)	3. Reptiles
4. Mammals	4. Cultivated grains and miscellaneous seeds
5. Reptiles	5. Fruits
6. Cultivated grains and miscellaneous seeds	6. Birds and eggs
7. Birds and eggs	7. Invertebrates (other than insects)

[1] Listed in the order of frequency of occurrence in 259 scats and of volume in 68 stomachs.

It was possible to identify positively only four species in the reptile remains that occurred in 18.9 percent of the scats and formed 10 percent of the total volume of food in the stomachs. With seven exceptions, reptiles were found only in the scats and stomachs in spring. No single species predominated, in either number or quantity, in the opossum's diet.

Although 25 stomachs and 100 scats were collected during the spring (April and May being an important nesting period for birds in Missouri), the study showed that birds and their eggs constituted a small portion of the diet of the animals examined. By volume, almost two-thirds of the bird remains encountered in the stomachs were those of chickens and their eggs, but even these were present in smaller amounts than might have been expected from the fact that nine of the animals examined were captured within a quarter of a mile of the University Poultry Farm, three of them on the farm itself. Even the presence of eggshells may not necessarily mean that the animals had raided the poultry-houses, for it was found that under certain conditions captive opossums ate the empty shells of hen's eggs. One scat contained the feathers of a crow; two stomachs contained the remains of a red-eyed towhee and a cardinal, respectively. One stomach contained feathers recognizable only as those of a native

sparrow, while another stomach and 10 scats contained traces of feathers that were unidentifiable even to family.

Of the cultivated grains and miscellaneous seeds, corn was the only one which the animals are believed to have taken for food. The others were probably ingested with food, since they were present only as traces in the stomachs. Corn was taken more frequently during the winter than in the fall or spring; it was found in 17 percent of the winter droppings but in only 2 percent of the fall droppings and 9 percent of the spring droppings. The fact that only the stomachs taken during January and February contained corn may be reason to believe that corn is eaten only when other foods are less available.

A number of scats and stomachs contained traces of dry leaf-fragments, twigs, and rotted wood, and practically all of them contained opossum hair. A small piece of cellophane bearing the word "bacon" was found in one stomach. The writer does not believe, however, that any of these was taken as food; rather, like the miscellaneous seeds, they were probably swallowed along with food. The presence of hair is undoubtedly the result of the animal's habit of licking itself. No green leaves, roots, or buds of any kind were found, and although the forest complex in central Missouri is principally oak-hickory, nuts were never encountered.

Captive opossums were often used during the study to test the validity of earlier contentions regarding their feeding habits. One contention worth mentioning is that scats found in the field which contain large numbers of persimmon seeds are those of opossums. Nineteen scats resulting from food taken in the wild were found to contain the remains of persimmons, yet not one contained their seeds. Even when persimmons were fed exclusively to eleven animals for an entire week, it was found that the seeds were not habitually swallowed; only one scat, out of 63 collected, contained a persimmon seed. In this connection it is interesting to record that of eight scats secured from two captive raccoons which were fed persimmons exclusively for a short period, each contained three or more seeds. It is likely, therefore, that scats found in the field which contain large numbers of persimmon seeds are those of raccoons or other mammals, not of the opossum.

The data regarding food habits, although inadequate for permanent or sweeping conclusions, lead the writer to disagree with the contentions of some earlier investigators that the opossum readily consumes practically anything edible, and even with Lay's statement (*op. cit.*) that "almost any vegetable or animal food is acceptable." Although the opossum is clearly omnivorous in the accepted meaning of the term, the present analyses, supplemented by feeding experiments with captives, indicate that it displays a distinct preference for animal material, particularly for insects. In central Missouri, corn is probably the only vegetable matter commonly consumed, other than fruits and berries.

DENNING

Yeager (*op. cit.*) found that opossums in Mississippi utilized a wide variety of dens: cavities in horizontal logs, holes in the ground, cavities in standing trees, piles of debris, tree stumps, vinebush tangles, squirrel nests, and the attics of

abandoned houses. Lay (*op. cit.*) noted that all of the seven opossum dens on 102 acres of Texas prairie were in ground burrows.

Of the 45 opossum dens located in the present study, 23 (51%) were in cavities on rocky slopes. Much of the area in which the study was conducted lies within the Northern Ozark Border, a structurally warped region in which many outcrops of bedrock occur. The limestones are broken by fractures and faults in which solution has been active, resulting in the formation of numerous small caverns. These seemingly afford excellent protection against both adverse weather and enemies, and when available they are generally used for dens in preference to other types of shelter.

Four dens were found in ground burrows that obviously had been dug by woodchucks (*Marmota monax*), 5 were in large trash heaps, 4 in old squirrel nests, 3 in hollow trees, 3 under farm buildings, 2 in horizontal logs on the ground, and 1 under a beehive.

One opossum, a female carrying young, was found in an abandoned squirrel nest which had been greatly enlarged by the addition of dry grass, corn husks, and oak leaves. It was located 14 feet from the ground in a red-oak tree (*Quercus borealis maxima*) growing in a fencerow on a prairie northeast of Columbia; it measured 55 inches in depth and 28 inches in diameter at the widest point. A somewhat smaller nest of the same type containing opossum hair was discovered nearby. Farmers living in the region state that during the winter such nests inhabited by oppossums are not uncommon. Abandoned nests of squirrels and crows are said to be used for the foundations and other materials are added to them, presumably by the opossums. In view of the opossums' habit of building nests inside their dens, it is quite possible that in areas such as this one, where there is an almost complete absence of ground cavities and other natural dens, some individuals carry materials to enlarge tree nests. The habit of building nests inside dens has been mentioned by Lincecum (1872), Pray (1921), Coghill (1939), and Hesselschwerdt (1942), and the procedure was described by Smith (1941). During the present study, captive opossums were frequently observed carrying leaves and paper into their dens by the use of the tail. In one instance, eight den-boxes were filled with leaves by five individuals in one night. With only two exceptions, all of the dens that were located in the wild during the present study contained dry leaves, grass, or corn husks, presumably carried there by the animals. The presence or absence of these nesting materials was taken as a criterion in deciding whether the holes into which the opossums were chased by the dogs at night were their dens.

The abundance of cavities on slopes, and the animal's ability to adapt to its own use such a wide variety of other types of shelter, lead the writer to doubt that shortage of dens is at any time a limiting factor for opossums in this part of the state.

More than one individual was found occupying the same den on only three occasions. In each instance the individuals were of the same sex: three females in September, two females in November, and two males in December. At no time were opossums found occupying dens with other species of mammals.

HOME RANGE

The wandering habit of some opossums was noted long ago by Lincecum (*op. cit.*), who said: ". . . I have two or three times found them under the floor of dwelling houses, where they had been for some time and had evidently taken up winter quarters, but they did not remain there long, nor do I think they dwell long at any one place." Hesselschwerdt (*op. cit.*) placed den-boxes in hedgerows on the Illinois prairie and found that an opossum did not use any one box for "any length of time." Lay (*op. cit.*) found that only 29 of 117 individuals trapped during a two-year period in Texas furnished sufficient information for the mapping of home ranges. His study indicated that almost half of the population on the area consisted of itinerants.

Much hunting during the present study was done on a strip of mixed-age-class oak-hickory woodland, approximately 2 miles long and ½ mile wide, bordering the eastern and southern city limits of Columbia. During the open hunting season (December 1941 and January 1942), hunters and trappers apparently depleted the tract of its opossum population, for although the area was hunted intensively by the writer for several nights after the season closed, no opossums were taken. Between the latter part of February and June, however, the area yielded 17 adults, indicating that it had been rapidly repopulated.

A total of 53 adult or subadult individuals was taken from this area during the period from September 15, 1941, to June 15, 1942. Thirty-four of these animals and eight taken elsewhere were released on the area. Although new individuals were continually captured there, only five of the marked animals, all females, were recovered during the nine-months period. Four of these were retaken only once: one approximately 1,000 feet from the point of release 52 hours later, one between 1,000 and 1,500 feet 63 days later, and two between 1,500 and 2,000 feet 24 days and 87 days later, respectively. Only one animal furnished additional information which might indicate a tendency to remain upon the area. This was a small female, weighing slightly less than a pound when she was first captured on October 21, 1941. She was released at the point of capture, and on December 18, 58 days later, was found 510 feet away. She was held in captivity until March 12, when she was released at the point of original capture. On April 17 she was again recaptured 950 feet away, this time with small young in the pouch.

Early in the study, a second area was established upon which 26 animals were released. Sections a mile in radius around the releasing stations were then hunted for eight nights at intervals of from one to two weeks. Since none of the marked animals was recaptured and but three new individuals were taken, the area was abandoned.

The only other information regarding range that was obtained was that from an adult male opossum tagged and released in March, 1942. This individual was reported to have been trapped by a farmer during the open season (December 1942 or January 1943) at a distance of seven miles from the point of release. Unfortunately, however, no additional data could be obtained.

The rapid influx into a depopulated area, the prompt disappearance of all but five of the released animals, and the reported recapture of one individual seven miles from the point of release all suggest that most opossums in this region are nomadic and that few of them establish a fixed home range in the fall, winter, or spring. Summer range conditions were not studied.

WINTER ACTIVITY

From weekly examinations of the pelts purchased by fur dealers in the vicinity of Columbia during the open hunting and trapping season, the investigator found that the sex ratio varied considerably in successive weeks. Examination of the reports from the U. S. Weather Bureau at Columbia revealed a correlation between the prevailing temperature and the ratio of males to females killed. During six weeks of the season when the mean temperatures averaged 41° F., the sex ratio among 686 individuals taken was 52 males to 48 females; while during the other three weeks, when the mean temperatures averaged 24° F., the ratio among 390 individuals was 68 males to 32 females.

A plausible explanation for these findings is that females are less active than the males during the coldest weather. Relatively greater activity among males than among females during colder periods has been reported in the case of the striped skunk by Hamilton (1937) and Allen (1939), each of whom found that most female skunks become inactive during cold weather, while some males are more or less active throughout the winter. Hamilton (*op. cit.*) stated that female skunks are "confirmed hibernators." The opossum cannot be considered a true hibernator since, according to Johnson's data (1931), it experiences a fluctuation in body temperature of not more than 2° C. even when subjected to refrigerator temperature of 4°–6° C. Nevertheless, the data obtained suggest that pseudohibernation or merely "denning up" during extremely cold weather occurs much more commonly among female than among male opossums.

HABITATS

During the study, many types of habitat, including cultivated areas, pasture, prairie, and woodland, were hunted with dogs. The type most favored by opossums seemed to be mixed-age-class wooded areas along small streams less than 15 feet wide and from 3 to 12 inches deep. Eighty-three of the 116 individuals captured with dogs were from such areas, while 21 were found in similar areas along streams larger than those described above; 12 were near ponds or lakes. The greatest distance from water at which any individual was taken was about 750 feet; 13 (11%) were captured 400 to 600 feet from water; 23 (20%), 100 to 400 feet from water; and the remaining 79 (68%), at the water's edge or less than 100 feet away.

In several cases the animals ran toward the nearest stream or pond when pursued by the dogs. How often this happened is not known because the dogs were "silent trailers," but such action may account, at least to some extent, for the high proportion of the captures in the immediate vicinity of water.

Lay (*op.cit.*) found that the distribution of open water seemed to determine the distribution and number of individuals that remained on his study area. During droughts the opossums left his area to go to surface water several hundred yards away.

Since it is a matter of common knowledge that opossums are occasionally encountered much more than 750 feet from water, more information concerning the influence of water upon the distribution of the species should be obtained before any generalization can safely be made. Nevertheless, it seems probable that the proximity of water is a factor essential to suitable opossum range.

PARASITES

The opossums collected in Missouri were relatively free of external parasites. The American dog tick (*Dermacentor variabilis*) occurred on the ears of 19 of the 143 individuals and a flea (*Opisodasys* sp.) was found on 5. Specific identification of the flea was not possible because only females were found. Neither of these parasites was present on the animals taken during the fall and winter.

The nematode *Physaloptera turgida* was found in the stomach and the nematode *Cruzia tentaculata* in the caecum. Every stomach and caecum examined contained six or more of these worms.

SUMMARY

1. During the study 116 opossums were captured with the aid of dogs, and 27 were either live-trapped, found freshly killed, or received by the investigator from other sources.

2. The breeding season in central Missouri (from the first matings to the weaning of the last litters), as indicated by the estimated birth-dates of 40 litters and the known birth-dates of two, extends approximately from the first of February to the first of September.

3. Two litters per year are usual in central Missouri, most of the first litters being born during the last two weeks of February, and most second litters during the last two weeks of May or the first week in June. There was no indication that any female produced a third litter.

4. The average number of young in 42 litters was 8.9. The largest number in any litter was 13; the smallest, 5.

5. The sex ratio among 120 individuals obtained alive was 55 males to 45 females. The ratio among 1,076 animals that were sold to fur dealers was 58 males to 42 females.

6. Frequency of occurrence of the various classes of food in 259 scats collected from the animals themselves from September to May, inclusive, was: insects, 87.6%; fruits, 50.6%; invertebrates (other than insects), 32.4%; mammals, 28.2%; reptiles, 18.9%; cultivated grains and miscellaneous seeds, 12.7%; birds and eggs, 8.9%.

7. Analysis of the contents of 68 stomachs taken during the period from December to May, inclusive, showed the following percentages by volume of the various classes of food: insects, 34.2%; mammals, 32.3%; reptiles, 10.0%;

cultivated grains and miscellaneous seeds, 7.3%; fruits, 6.8%; birds and eggs, 4.9%; invertebrates (other than insects), 4.5%.

8. Twenty-three of 45 opossum dens discovered during the study were in caverns in rocky slopes, 4 were in ground burrows durg by woodchucks, 5 in large trash heaps, 3 in squirrel nests, 3 in hollow trees, 3 under farm buildings, 2 in horizontal logs on the ground, 1 under a beehive, and 1 in a tree-nest that apparently had been constructed at least partially by the opossum occupying it.

9. The subsequent recovery of only 5 of 68 released animals, the reported capture of one individual 7 miles from the point of release 9 months later, and the rapid repopulation of an area devoid of opossums at the close of the hunting season indicate that most opossums are nomadic.

10. During six weeks of the open hunting season (December 1941 and January 1942) when the mean temperatures averaged 41° F., the sex ratio among 686 individuals taken by hunters and trappers was 52 males to 48 females, whereas during the remainder of the season, when the mean temperatures averaged 24° F., the ratio among 390 individuals was 68 males to 32 females. This probably indicates a decrease in activity among females during cold weather.

11. The greatest distance from water at which any individual was captured was about 750 feet. It is likely that the proximity of water is a factor important to suitable opossum range.

12. The dog tick (*Dermacentor variabilis*) and a flea (*Opisodasys* sp.) were the only external parasites found. The only internal parasites found were two nematodes—*Physaloptera turgida* in the stomach and *Cruzia tentaculata* in the caecum.

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THE COTTONTAIL RABBITS OF VIRGINIA

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From 1939 to 1941 a major project of the Virginia Cooperative Wildlife Research Unit[1] was the study of the cottontail rabbits (*Sylvilagus*) of Virginia. The primary objectives were to determine the distribution of all named forms found in the state and to obtain all possible information on the breeding habits and other factors which might be of interest in their management. During 1939–41, 180 adult specimens of the cottontail were collected from all parts of the state, representing 65 of its 100 counties. A few specimens have been taken since 1941 by other members of the Unit, and, in addition, the Virginia cottontails in the U. S. National Museum and the Biological Surveys Collection of the U. S. Fish and Wildlife Service were studied, so the present paper is based on the study of nearly 250 specimens. The majority of the specimens prepared during the study were deposited with the Biological Surveys Collection of the Fish and Wildlife Service, but some were retained by the senior author, some by the Virginia Cooperative Wildlife Research Unit, and some were given to the Carnegie Museum.

Cottontails are important game animals in Virginia. It is possible that even today more cottontails are shot than any other game (the possible exception is the gray squirrel) in spite of the fact that widespread fear of tularemia in recent years has caused a decline in hunting. Until 1936 it was legal to sell cottontails either dead or alive if they had been shot or trapped during the legal open season, November 15 to January 31, and many thousands, possibly hundreds of thousands, were sold on the markets in the larger cities, and in general stores in the

[1] Virginia Commission of Game and Inland Fisheries, Virginia Polytechnic Institute, American Wildlife Institute, and U. S. Fish and Wildlife Service cooperating.

smaller towns. In 1936 the law was changed to prohibit the sale of rabbits that had been shot, but it was still legal to sell rabbits that had been trapped, so trapping for the market continued. In 1941, however, the sale of all wild rabbits was prohibited.

The season for hunting and trapping rabbits has opened on either November 15 or 20 in all recent years and it has continued into or through January in most counties. Landowners or tenants, however, are allowed to kill rabbits on their own land for their own use during the closed season.

There is no thoroughly satisfactory basis for an estimate of the annual kill of rabbits in Virginia by hunters and trappers, but for several years the State Commission of Game and Inland Fisheries requested each of its county game wardens to estimate the kill in his own county. The aggregate estimate varied between 290,000 and 480,000, the best figures available. It has been the experience of the other states using this method that the wardens' estimates of game killed are usually low (Gordon, 1940). We suspect that the actual kill of rabbits by hunters and trappers in Virginia is near one million animals each year. The number of licensed hunters in the state has varied between 130,000 and 152,000 during the past 15 years, but rabbits may also be taken by resident trappers under 16 years old, and by anyone on his own land without a license. Neither is a license required of anyone to trap rabbits with a box trap.

In recent years there has been some interest in restocking areas that have been depleted of rabbits by transplanting live-trapped animals from other portions of the state. So far as we know there have never been any introductions into Virginia from other states, and even the transplantations within the state have been small and insignificant. Virginia is one of the few remaining Eastern States where the natural distribution of cottontails has yet been little disturbed by artificial stocking, and the present study is therefore particularly timely. It is our feeling that whenever possible artificial transplantation of game should be within the normal range of the species and subspecies, and the present study has enabled us for the first time to delineate the natural range of the five forms of cottontails found in Virginia.

The measurements and weights recorded herein were made by the senior author, with the exception of a few added after he left the Virginia Cooperative Wildlife Research Unit.

Three species of cottontails are found in Virginia—*Sylvilagus palustris*, *S. transitionalis*, and *S. floridanus*. Only the last one is common and state-wide in distribution. The first two are very limited in their distribution and are found in habitats not easily hunted so they are rarely taken by hunters. It is doubtful if they constitute 1 percent of the total annual bag of cottontails in Virginia each year. *S. floridanus* is, or was, represented by three subspecies in the state. The insular race, *S. f. hitchensi*, may be extinct.

No attempt is made here to give complete descriptions of all the races discussed. Those characters that we have found most useful in distinguishing between the Virginia forms will be emphasized, and the first and most abundant form is described as a point of reference.

RACES OF COTTONTAILS IN VIRGINIA

Sylvilagus floridanus mallurus (Thomas)

Eastern Cottontail

This, the most widely distributed race of rabbits in Virginia, is found in all except the southwesternmost counties and on some of the coastal islands (see Map 1). It is found from sea level to an altitude of 3,000 feet, or beyond, but is replaced in the higher wooded mountain areas by *S. transitionalis*. There is some overlapping between the ranges of these two species, but in general the eastern cottontail is found in more open brushy habitat, while the New England cottontail occurs in the denser woods.

Characters.—The differences between *S. f. mallurus* and *S. f. mearnsi*, in the Virginia material studied, are qualitative only. There were no significant differences in skull or body measurements (see Table 1). In *S. f. mallurus* the top of the head and back is a rusty buff with an overwash of black-tipped guard hairs, giving a pencilled or streaked appearance; nape rich rufous; rump patch distinctly grayish; top of tail faded rufous; sides paler light buff; ears grayer than body, with usually a narrow indefinite edging along the anterior margin and tips; insides of ears light gray and thinly furred; underside of tail and belly white, except for golden tan under the neck; white undersurface extends onto legs; tops of legs and fore-feet pale rufous; tops of hind feet white or mixed pale buff and white. This is the average coloration for fresh pelage. The coloration for the race as a whole shows considerable individual variation as well as seasonal variation.

The main difference between our specimens of *S. f. mallurus* and *S. f. mearnsi* is that *mallurus* is distinctly brighter reddish on the back. When a series from the southwesternmost counties is compared with a series from the remainder of the state, this difference is easily observed, but it would be difficult to place one individual. In the zone of intergradation in Tazewell, Bland, Smyth, and Washington counties, most specimens are intermediate between the two races.

The weights included in Table 1 are those collected during the 1939–41 study and they represent specimens taken in all portions of the range of each form. In 1943 and 1944, a total of 145 eastern cottontails were live-trapped during late February and early March at Blacksburg on the Quail Demonstration Area. Their weights are presented as an indication of the variation that may occur at one locality.

In both sexes the weights were substantially higher in 1944 than in 1943 although the largest individual was taken in 1943. The reason for this difference was not determined.

When the weight data were carefully analysed month by month there was noted a general tendency for the animals to fatten for the winter and to hold their weight during the winter. With the coming of spring the males lose weight slightly while the females gain, presumably because of pregnancy.

Sylvilagus floridanus mearnsi (Allen)

Mearns Cottontail

This race had not previously been reported for Virginia nor were Virginia-taken specimens found in the museum collections examined. Howell (1909) mentioned a specimen from Campbell County, Tennessee, about 20 miles from Virginia. A. B. Brooks (1932) reports it from the middle and western parts of West Virginia. Nelson's (1909) generalized map includes southwestern Virginia in the range of *S. f. mearnsi*, but this was simply a prediction not based on any specimens examined.

The cottontails from the six southwesternmost counties of Virginia (see Map 1), however, are definitely paler and grayer than those from farther east, and are referable to *mearnsi*. Nelson (1909) describes *mearnsi* as possessing shorter ears, but in the Virginia material this difference did not appear.

When compared with the eastern cottontail, the *mearnsi* is more grayish, with less pinkish buff on the back, darkened by an overwash of dark guard hairs. This dark over-

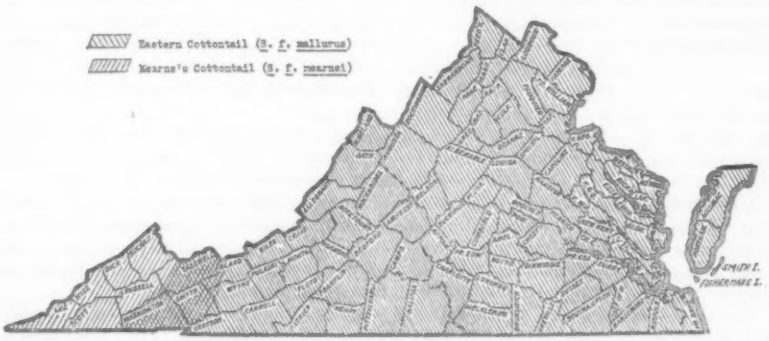
TABLE 1.—*Average measurements in millimeters and weights in grams of cottontail rabbits of Virginia*

	S. FLORIDANUS MALLURUS		S. FLORIDANUS MEARNSI		S. FLOIDANUS HITCHENSI		S. TRANSITIONALIS		S. PALUSTRIS
No. measured	152		23		3		8		2
Total length	426.9	(320–500)	422.9	(330–483)	425.0	(375–477)	395.6	(355–434)	447.5
Tail vertebrae	48.9	(25–65)	49.1	(42–60)	58.3	(50–70)	47.1	(40–51)	40.0
Hind foot	94.1	(83–110)	95.1	(90–102)	94.0	(90–97)	91.9	(81–110)	99.0
Ear (from notch)	62.5	(56–70)	62.6	(55–71)	55.5 (dried)	(54–57)	57.9	(55–61)	—
No. skulls measured	100		13		4		5		1
Greatest length of skull	73.4	(66.8–78.0)	72.0	(68.2–76.4)	75.0		68.5	(66.5–74.5)	82.8
Parietal breadth	27.2	(26.4–29.9)	27.7	(26.4–28.5)	28.9		26.4	(25.0–28.0)	30.6
Interorbital breadth	18.1	(15.4–20.0)	18.8	(16.4–20.2)	18.1		16.5	(15.0–17.3)	18.3
Breadth of rostrum above premolars	16.1	(14.0–19.0)	16.9	(15.2–19.8)	21.4		17.0	(15.5–18.7)	18.4
Depth of rostrum above premolars	15.6	(12.9–18.0)	15.4	(14.5–16.1)	17.8		14.2	(13.1–15.5)	18.8
No. males weighed	87		10		—		2		—
Weights of males	1144.0	(646–1435)	1179.5	(938–1250.5)	—		990.0	(830–1150)	—
No. females weighed	82		10		—		2		—
Weights of females	1231.2	(784.5–1496)	1233.9	(1033.4–1493.8)	—		868.5	(827–910)	—

wash, however, is not as characteristic in specimens from Virginia as in those examined from some of the central states. The rump patch averages more conspicuous, although a few specimens of the eastern cottontail examined from Virginia had a grayer rump patch than any of the Mearns cottontails. The chestnut nape patch averages smaller and duller than that found in the eastern cottontail. The top of the tail is less rufous while the black streak on the cheek is heavier.

TABLE 2.—*Weights in grams of cottontails at Blacksburg, Va.*

	MALE	FEMALE
1943		
No. weighed	50	40
Average weight	1039	956
Range in weight	708–1361	652–1418
1944		
No. weighed	34	21
Average weight	1105	1190
Range in weight	567–1361	1022–1361
1943–1944		
Total no. weighed	84	61
Average weight	1066	1037



MAP 1. Distribution of *Sylvilagus floridanus* in Virginia. Hitchens Cottontail (*S. f. hitchensi*) has been taken only on Smith and Fishermans Islands.

Sylvilagus floridanus hitchensi Mearns

Hitchens Cottontail

Hitchens cottontail is a well-defined race known only from Smith Island and Fishermans Island off the coast of Northampton County, Virginia (see Map 1). It is not improbable that it is, or was, found on some of the nearby islands also, but they have not been surveyed intensively enough for a definite determination. A severe hurricane which swept the Eastern Shore in August, 1933, inundated the islands in question and probably exter-

minated the race, because residents have reported no rabbits seen there since. Mearns (1911) in his original description, quotes Captain George Hitchens of the Coast Guard as saying that the rabbits had existed continuously on the islands for more than 50 years.

This race is about the size of the eastern cottontail but it is paler, and there is also less contrast between the colors. The overwash of black on the guard hairs is absent. The brown of the guard hairs on the back aligns itself to form streaks of varying sizes and patterns, while the light brown is so predominant that a general sandy appearance results. The line marking the darker back from the lighter sides is not as distinct as in the average eastern cottontail of the mainland. The chestnut nape is not as distinct as in the mainland form and seems to carry back broader. There is less hair on the inside of the ears than in the eastern cottontail; furthermore, the outside margin of the ears is only slightly darker than the adjacent color and no distinct marginal line is apparent. The chestnut on the back of the hind legs is darker than that of the mainland form and the fur has the appearance of being coarser and heavier, giving the animal a shaggy appearance.

The skull appears to be heavier than that of the eastern cottontail. The teeth are also heavier, increasing the length of the molar series; the interorbital breadth is greater; the rostrum is thicker; and the audital bullae are greater in diameter (see measurements in Table 1).

This race stands out distinctly when compared with the mainland form. It was thought by some to be a hybrid, but Mearns (*op. cit.* writes: "At one time a number of 'Australian rabbits' were introduced but speedily died out. . . . It is in fact a pure cottontail, showing no trace of admixture with the genus *Oryctolagus*."

Sylvilagus transitionalis (Bangs)

New England Cottontail

The New England cottontail seems to be definitely limited in Virginia to the higher Allegheny and Blue Ridge mountains (see Map 2). Nelson's reference (1909) which includes Alexandria, Virginia, and "near sea level in Virginia" was evidently based on a specimen prepared by Vernon Bailey. Mr. Bailey (1933) clears this record up by stating ". . . a specimen which I bought on January 1, 1904, of a colored man on the street, who said he killed it at Alexandria, probably came from West Virginia where they are common and are often included in shipments of rabbits to market. At that time I did not know that men posing as hunters went about the streets selling game from the market stalls, and recognizing an interesting specimen, I saved it and labelled it as coming from Alexandria. These cottontails belong to the Transition Zone of the Allegheny Mountains. . . ."

All specimens examined were taken at elevations above 3000 feet in the Allegheny Mountains. Signs indicate that these cottontails occupy the woods and brush along most of the higher crests and ridges of the state. We believe that this race will be found on all the higher peaks above 3000 feet, as shown on Map 2, but thus far we have taken it only in Roanoke, Giles, and Highland counties, at the points indicated.

This species is the smallest found in Virginia. It is similar to the eastern cottontail (*S. f. mallurus*) in color, except for specific differences noted below. The skull is also lighter and readily distinguishable from any other cottontail in Virginia.

The short rounded ears have a black margin on the outside, making a distinct black line (*i.e.* the black does not blend gradually into the browner color of the ear as is true in most specimens of the eastern cottontail). A definite black patch is found between, and just in front of, the ears. The underfur is dark gray (much darker than that of the eastern cottontail). The back is dark ochraceous buff, overlaid with an overwash of black-tipped guard hairs that in some specimens give the back a dark appearance. Virginia specimens examined do not have the "rich reddish" color so often attributed to the New England cottontail. In fact, many of the eastern cottontails examined from Virginia are a much "richer reddish" than the species under discussion.

The skull is light and slender, the interorbital breadth narrow, and the rostrum thin and decurved anteriorly. The supraorbital process is very thin, narrowing in front so that the anterior process and notch are practically absent. The posterior process narrows to a thin lanceolate point quite frequently free of the skull, leaving a distinct foramen. The zygomatic arch is thin and the jugal small. The characteristic supraorbital process will at once serve as a distinguishing criterion when an adult skull is available. In addition, as pointed out by C. E. Friley, Jr. in Dalke and Hosley (1942), the posterior margin of the nasals is quite jagged in this species, and smoother in *S. floridanus*. This character and the lack of the anterior supraorbital notch already mentioned constitute the best skull characters.

MAP 2. Distribution of *Sylvilagus transitionalis* and *S. palustris palustris* in Virginia. —The New England Cottontail (*S. transitionalis*) likely occurs throughout the Transition Life Zone as shown by the black areas on the map; however, specimens were taken only in Giles, Highland and Roanoke counties. The Carolina Marsh Rabbit (*S. p. palustris*) is confined to Nansemond, Norfolk and Princess Anne counties.

Sylvilagus palustris palustris (Bachman)

Carolina Marsh Rabbit

The marsh rabbit occurs in the lowlands and marshes in Nansemond, Norfolk, and Princess Anne counties (see map 2). H. H. Bailey (1930) reports taking the species during high water from the brackish marshes of Lynnhaven and down the coast to Back Bay, Princess Anne County. Lewis (1937) considers this rabbit "common in the Dismal Swamp and in the freshwater tide marshes along the headwaters of the Elizabeth River." There are four specimens in the National Museum from the Dismal Swamp in Virginia.

This species is about the same size as the eastern cottontail but is much darker in color and lacks the white "cottontail." The back is generally dark with a heavy overwash of black. The nape has a small patch of faded buff; a lighter grayish streak in front extends to the base of the ears and covers most of the interior of the ears. The forehead loses part of its overwash of black and appears more rufous. The color of the back runs well down on the sides, partially covering the belly. Only about half, or a little over, of the belly is grayish white. The underchin is dark gray with some tips of white guard hairs protruding. Underparts of legs and tail have a faded chestnut color. The toenails of the hind feet are very conspicuous and the feet appear small because of the absence of the heavy covering of hair found in other species of *Sylvilagus* from Virginia. The dark underside of the tail distinguishes this species at once from the "cottontails."

The skull is massive, being larger and heavier in every respect than that of any other race of *Sylvilagus* in Virginia. There is usually a small notch in the anterior process and a slit foramen in the postorbital process. This process is fused to the skull by a broad tip. The zygomatic arch is very heavy and the jugal is deeply grooved. The bullae are comparatively small and firmly joined to a heavy basioccipital.

REPRODUCTION

The data on reproduction are based on the eastern cottontail only, the commonest race in the state. The earliest breeding date available was from a specimen collected in Bath County March 21, 1941, at which time parturition had already occurred, so breeding must have taken place about the middle of February. This is undoubtedly an exceptionally early record, however. It is probable that on the average breeding first occurs in March. All females collect in April were either pregnant or lactating; this was also true in May with but two exceptions.

The number of embryos in 21 females ranged from 2 to 6, averaging 4.7. Only one had 2 embryos, one had 3, seven had 4, seven had 5, and five had 6. In Michigan, Trippensee (1934) and Haugen (1943) report Mearns cottontail as bearing an average of 5 and 5.4 young, respectively.

The breeding condition of 63 males was checked during January, February, and March by noting the weight of the testes and whether they had descended into the scrotum. The latter criterion was not always reliable, since recently or partly descended testes would often recede when the animal was picked up or jerked by the hind legs. In weighing the testes, it was found that in a few cases they were equal in size, but in most instances one was larger than the other. This difference was at times as high as 25 percent but it usually was less than 5 percent. No significant difference in the weights of the right and left testis was found. The right testis averaged 8.3 grams; the left, 8.4 grams. The weights of the testes showed a definite trend toward an increase during January, February, and March.

Data on 234 cottontails were available for the summary of sex ratios. Of these, 123 were males and 111 females; a ratio of 111 to 100. In an analysis by months it was interesting to note the preponderance of males over females during the months of February and March which would imply that there is some truth in the statement so often made by hunters that the females are less active during severe weather. During the height of the breeding season in April and May, this ratio was reversed.

The rabbits trapped at Blacksburg in February and March of 1943 and 1944 showed the same preponderance of males over females, 84 to 61, or a ratio of 123 to 100.

PARASITES AND DISEASE

We cooperated with the U. S. Public Health Service in a study of tularemia by furnishing 75 rabbits for examination, and we, in turn, received reports on

the findings of parasites and disease. For these data we are indebted to Frederick Bell and William Chalgren.

Practically all rabbits collected were infested with fleas, and all except the winter specimens had ticks in varying numbers. The most abundant flea was *Cediopsylla simplex*, often numbering more than 100 on one rabbit. *Odontopsyllus multispinosus* and *Ctenocephalides canis* were also found. Mites (*Trombicula microti*) were numerous also with sometimes 50 or more on a rabbit.

Ticks were found mainly during the warm weather and at times were quite abundant. For example, 300 ticks were removed from one specimen collected early in October. The species found most commonly was the rabbit tick (*Haemaphysalis leporis-palustris*. The tick (*Ixodes dentatus*) was found frequently but usually in smaller numbers than the rabbit tick. Necrotic nodules were often found under the skin at the site of attachment of these parasites.

It is interesting to note here that the rabbit is an important host for the common chigger (*Entrombicula alfredeugesi*) Oudemans. In this connection, Ewing (1929) states, "The rabbit, of all our wild mammals and the box turtle, of all our reptiles, appear to be important hosts of chiggers."

Less attention was paid to internal parasites, but a few of the macroscopic parasites were so much in evidence as to deserve mention. Practically every specimen was infested by tapeworm (*Taenia pisiformis*) cysts which were often found in the peritoneal and thoracic cavities. The liver often showed scars caused by these parasites.

Summer and fall specimens often were infested with the warble fly (*Cuterebra*). These larva were usually found under the neck and sometimes on the back. They apparently cause little injury to the animal but are very unsightly.

A few specimens (averaging about 2 percent infection) were found to be infested with the nematode *Dirofilaria scaphiceps*. These were usually found in coils in the intermuscular fasciae of the hind leg, although, in one specimen they were found in the subcutaneous fascia on the back just back of the shoulders.

The intestinal tract of one specimen submitted for study was found to contain an unusual variety of parasites: in the stomach, a few specimens of the rabbit stomach nematode (*Obeliscoides cuniculi*); in the small intestine, a heavy infestation of the trematode (*Hasstilesia tricolor*) and one tapeworm of the genus *Cittotaenia*; in the cecum, the rabbit whipworm (*Trichurus leporis*); and in the large intestine, 16 specimens of the nematode (*Dermatoxys veligera*). In addition, this rabbit suffered from a severe infection of coccidia.

Tularemia is not a major disease in Virginia, but its occurrence is frequent enough to cause considerable fear among hunters and persons handling wild rabbits. In fact, most of the cases of the disease in Virginia have come from handling rabbits. In this connection, Dr. William Grossman, Director of Bureau of Communicable Diseases, states: "Though we are unable to give you any exact figures at this time, we do know that by far the majority of these cases were infected as a result of dressing or preparing wild rabbits. A few cases have been reported resulting from the bites of ticks."

The total number of cases of tularemia in Virginia for the ten year period, 1931–1940, is given as follows:

1931— 43	1936— 57
1932—105	1937— 49
1933— 78	1938—144
1934— 57	1939— 81
1935—101	1940— 49

In collecting specimens for this study, no rabbits were encountered with tularemia as judged from gross postmortem examination. No bacteriological cultures were made or injections into test animals attempted by the writers. The worker always used the precautionary measure of wearing rubber gloves while skinning and preparing specimens, and this procedure is recommended also to those preparing rabbits for the table.

None of the 75 rabbits sent to the U. S. Public Health Service Laboratory was found to have tularemia, even when their tissues were injected into test animals, but when the ticks (*Haemaphysalis leporis-palustris*) from these rabbits were crushed and injected into test animals diseases were discovered in eleven cases. In addition to tularemia there were found Rocky Mountain spotted fever and American Q. fever. The ticks serve as reservoirs for the infections and may eventually infect the host animals (Ms. report from Dr. R. R. Parker, Director Rocky Mountain Laboratory, U.S.P.H.S.).

Inasmuch as the ticks drop off the rabbits upon the onset of cold weather, there is little opportunity for rabbits to become infected with tularemia during the winter, so human cases of the disease are unlikely to be contracted in winter. We believe that the danger of hunters and trappers contracting tularemia would be largely averted in Virginia if they handled rabbits only between November 20 and January 31.

SUMMARY AND RECOMMENDATIONS

Five races of cottontail rabbits belonging to three species, occur in Virginia. One of them, the Mearns cottontail (*Sylvilagus floridanus mearnsi*), is reported here for the first time. It occurs in six southwestern counties of the state, while the eastern cottontail (*S. f. mallurus*) occurs in the remainder of the state with the exception of Smith and Fishermans islands off the eastern coast of Cape Charles, where it is replaced by Hitchens cottontail (*S. f. hitchensi*). The New England cottontail (*S. transitionalis*) is found on the higher mountain peaks, above 3000 feet, and the swamp rabbit (*S. palustris*) occurs in the Dismal Swamp region of southeastern Virginia.

The height of the breeding season for the eastern cottontail in Virginia is March and April, but breeding continues through the entire year except in December and January. The average litter size based on embryo counts was 4.7. The sex ratio of 234 specimens from all parts of the state, taken mostly in the December to February period, was 53 males to 47 females. That of a group of 145 rabbits live-trapped at Blacksburg during February and March

was 58 males to 42 females. The figures show that males are more active than females during the winter months, and therefore are more easily taken then.

In transplanting cottontails from one section of the state to another, it is recommended that only cottontails of the same race as those originally present in the region being restocked be released there.

Tularemia is not a common disease among rabbits in Virginia, but the rabbit ticks are often carriers of the disease and may transmit it to rabbits. Rabbit ticks are also found to be carriers of Rocky Mountain fever and American Q. fever. After the ticks drop off the rabbits to hibernate in the ground, which is likely to occur during mid-winter in Virginia, there is relatively little danger of humans contracting tularemia by contact with rabbits. Present laws in Virginia which prohibit rabbit hunting until the opening of the general hunting season, November 15 and November 20—west and east of the Blue Ridge Mountains, respectively—protect the licensed hunters to which these regulations apply, but landowners or tenants are still allowed to take rabbits for their own use on their own land at any time. It is recommended that as a public health measure the taking of cottontails be completely prohibited to all until the opening of the general hunting season.

Assistance in this study was furnished by many people, to whom we are very grateful. In addition to those already mentioned in the text, we should like to acknowledge the aid given by the following: County game wardens of the Virginia Commission of Game and Inland Fisheries, who furnished many of the rabbits for the investigation; Drs. H. H. T. Jackson and Remington Kellogg, who allowed the use of specimens under their care in the Biological Surveys and National Museum collections, and in addition gave much valuable counsel; and C. O. Handley, Jr., who furnished some recent data on *Sylvilagus transitionalis*.

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Virginia Cooperative Wildlife Research Unit, Blacksburg, Virginia.

GROWTH AND BEHAVIOR OF YOUNG SEA LIONS

BY VICTOR B. SCHEFFER

A sea lion rookery at Northeast Point, St. Paul Island, Pribilof Group, Alaska, was visited seven times between May 23 and August 7, 1944. Four young sea lions (*Eumetopias jubata*) were taken as specimens and seven others, shot by natives for food, were weighed and measured.

A single newborn young found on May 23 established the starting date of the 1944 season of parturition. On this date the rookery was virtually free of snow, while Bering Sea drift ice along the shores of the island had been gone for two or three weeks. By May 30 there were 34 young here, two of them dead; by June 2 it was impossible to count the young because of the large numbers of adults covering the rookery; by June 12 there were 100–300 young and a few were still being born; on June 27 we recovered the body of a newborn sea lion that had been dead about one week. Thus, the season of parturition extended for about four weeks, between May 23 and June 20, and was at a peak about June 6.

The size of young sea lions is indicated in Table 1. An individual was judged to be newborn if it was dragging a fresh, pink umbilicus and had not yet cleared its intestine of meconium. The latter is a dark olive-to-black, gummy, odorless material which plugs the lower 75–90 centimeters of the colon. There is evidently little or no difference in size between the sexes up to the age of 6–10 weeks, although among the adults, the male attains several times the weight of the female. It seems likely that the body weight of the young doubles, and the body length increases by 25 percent, within the first seven weeks of life.

The pregnant female evidently gives birth to her young within less than one week of her arrival on the breeding ground. On May 23 we counted 11 females and one young; on May 30 about 150 females and subadult males (the two are indistinguishable at a little distance) and 34 young.

Our observations did not continue until the young were weaned, but stomach contents indicated that the young sea lions were still on a milk diet at the age of 6–10 weeks. Ascarid worms (*Porrocaecum decipiens*), which are nearly always found in adult stomachs, were not present in the young. The finding of more than one liter of thick, cream-colored milk in one stomach gives a clue to the rapid growth rate of the suckling young.

The sea lion is relatively well developed at birth (Pl. 1). The girth of the body is greatest at the belly, while later in life the girth is greatest at the shoul-

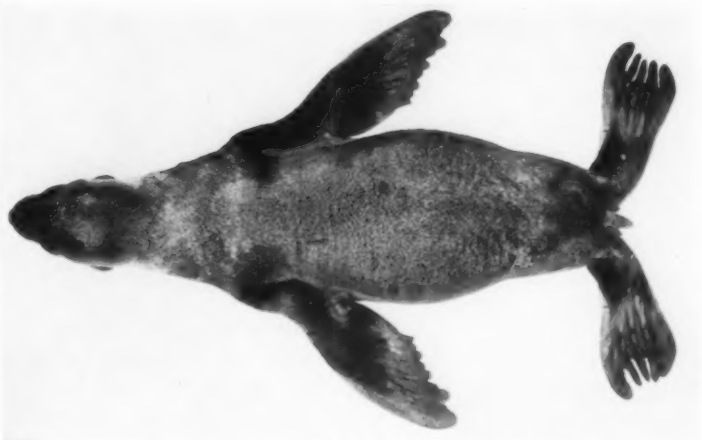

PLATE 1

Newborn sea lion, female, length 1077 mm, weight 49 pounds, St. Paul Island, Alaska, May 30, 1944. (Specimen B.D.M. 46.)

TABLE 1.—*Measurements of 11 young sea lions, St. Paul Island, Alaska, 1944*

DATE	SEX	WEIGHT, POUNDS	STANDARD LENGTH, MM.	CONTENTS OF STOMACH
		4—Newborn		
May 23	♂	37	933	Milk, 10 ml
May 30	♂	35	986	Bile and mucus
June 20	♂	41	1018	(Not examined)
Average	♂	38	979	
May 30	♀	49	1077	Milk, 10–15 ml
		7—Aged 6–10 weeks		
August 7	♂	73*	1194	Milk
"	♂	77*	1213	Pebbles and sand
"	♂	89*	1232	Pebbles and shell
"	♂	115*	1372	Milk, ½ l, pebbles
Average	♂	88*	1250	
August 7	♀	83	1258	Milk and pebbles
"	♀	89	1263	Milk and pebbles
"	♀	90*	1263	Milk, at least one l
Average	♀	87	1261	

* Bled weight plus 1 pound.

ders. In three newborn young that we examined, 12 teeth had erupted; in one newborn young, 11 teeth had erupted, as follows: Incisors $\frac{1,3}{1,2}$, Canines $\frac{1}{1}$, Postcanines $\frac{1,2,3}{1,2,3}$, = 12. In the case of the 41-pound male, left I_2 was visible but not right I_2.

The mating season of the sea lions probably extended through the month of June. Although we did not see copulation, the adult males were most belligerent and held their stations on the rookery most stubbornly during the period June 2 to June 18.

On May 30, at the approach of a man, two mothers attempted to carry their young to safety in their teeth. One animal was seized by the skin folds of its neck, the other by its rump. One was dropped on the rocks at the water's edge, the other in the sea about 6 feet from shore and subsequently paddled back to the rocks with its head and neck held high above the water. On June 12 a young sea lion was seen swimming for 5 minutes in quiet water, trying to climb on its mother's back or swimming slowly by her side. According to local belief, the sea lion mother "teaches" her young to swim. We would hardly refer this behavior to teaching, however, and would be inclined to feel that the young follows the mother into the water, becomes alarmed at the novel sensation, and attempts to crawl out on the mother's back. She pushes it away indifferently or swims about on her own business with the young following in her wake.

On June 18, Edward C. Johnston told us of seeing at least one young swimming in the surf. On July 17 all of the young, numbering several hundred, took to the water and swam easily with the adults seaward of a surf that was heavy enough to have swamped a dory. One small animal left the rocks and attempted to push through the surf, succeeding after three attempts. Another, slightly larger, entered the surf but returned quickly to shore near the observer. On August 7 the young were strong swimmers. Native hunters shot about 30 of them and hauled the bodies in through the surf by means of hook and line.

U. S. Fish and Wildlife Service, Seattle, Washington.

BRIEF COMPARISON OF SHORT-TAILED SHREW AND REPTILE POISONS

By Barbara Lawrence

A recent conversation with Mr. Arthur Loveridge about the properties of snake venom and its effects on animals has led me to believe that there may be a much closer relationship than has previously been supposed, both chemically and functionally, between the poisonous secretions of the parotid and sublabial glands in certain reptiles and the secretions of the submaxillary gland in *Blarina*, the short-tailed shrew. The poisonous nature of the latter was first studied and described by Pearson (1942). He calls attention to the fact that the gland involved in *Blarina* and in snakes is not the same, and (p. 165) says that "The toxic extract obtained from *Blarina*, however, appears to have some pharmacological properties similar to those of snake venoms." The scope of his paper does not call for a further comparison of the two, nor is any reference made to the poisonous saliva secreted by the sublabial gland of the lower jaw in the Gila monster. The striking similarity between the external symptoms produced by the venom of certain reptiles, particularly that of the cobra, and the poison of *Blarina* seems to me worth describing in the hope that it may stimulate further research on the nature and functions of the salivary glands not only in *Blarina* but also in the other Insectivora.

The reader is referred to Calmette (1908) and Noguchi (1909) for a detailed discussion of the nature of snake venom. Here it is sufficient to say that all snake venoms are made up of more or less the same components but in different proportions. Generally speaking, the most active substances are (1) a neurotoxin which attacks the nerve cells causing various kinds of paralysis and is responsible in some instances for respiratory failure and resultant death; (2) a hemorrhagin which breaks down the endothelial lining of the capillaries, causing severe bleeding; (3) a hemolytic agent which disintegrates the red blood cells; (4) a proteolytic diastase which acts on the fibrin of the blood and on the muscles; and (5) a thrombase which acts on the fibrin ferment to coagulate the blood. Various other cytolytic actions and a bacteriolytic action have also been observed.

There are two principal types of snake venom, that found in the viperines (vipers, rattlesnakes, copperheads, moccasins, etc.) and that found in the elapines (coral snakes, cobras, and other old world forms). The first type is characterized by its primarily hemorrhagic action. For this reason such local symptoms as swelling, bleeding, and discoloration of the tissues are very pronounced. As general poisoning develops, prostration, difficulty of locomotion, twitching, rapid and feeble pulse, labored breathing, and convulsions may occur. Elapine venoms in contrast with viperine, are remarkable for their strong neurotoxic and hemotoxic action and the development of only slight local symptoms. Dogs, guinea pigs, rabbits, and monkeys experimentally poisoned become lethargic and depressed, respiration becomes slower, paralysis appears, sometimes affecting the hind legs first, so that the limbs have difficulty in supporting the body, death

is preceded by convulsions and is due primarily to respiratory failure. All of these symptoms agree very closely with those observed by Pearson in mice injected intraperitoneally with extracts of the submaxillary gland of *Blarina*. In addition Pearson describes urination and convulsion in a rabbit injected intravenously, while Noguchi (1909, p. 118) says that "involuntary evacuations, often of a sanguineous character, may precede death, and are generally accompanied by convulsions." Ill-directed attempts at scratching with the hind feet are described by Pearson, while Noguchi further states that, owing to the paralysis of the motor nerve endings, the reaction to stimuli is destroyed or much reduced while the irritability of the sensory nerves is long retained. Pearson says more generally that his mice did not respond readily to stimuli. Observations on the effect on the heart are not directly comparable. Noguchi quotes Rogotzi as saying that cobra venom causes a rapid, transient weakening of the heart which soon regains its original activity. Calmette observes the same phenomenon followed by a secondary weakening of the heart. Noguchi found the action of the heart is quickened but of fair strength. Martin's work (1895) on the Australian black snake shows that the amount of venom injected has a direct relation to the reaction of the heart. Pearson's experiments carried out on an anesthetized rabbit and cat were, as he says, not conclusive. In one instance an initial drop in heart rate which then returned to normal is recorded; in another instance no initial drop was observed; when death followed, a secondary slowing or irregularity of the heart was noted. *Blarina* and both kinds of snake poison are reported to cause labored or gasping breathing.

Although in general the effects of Gila monster poisoning resemble those from snake venom, the symptoms do not resemble those of *Blarina* poisoning as closely as do cobra bite symptoms. Van Denburgh and Wight (1900) have summarized the results of numerous experiments with the Gila monster from which it appears that there is a neurotoxic action limited to the central nervous system and apparently affecting respiration and the heart. Certain changes in the coagulability and composition of the blood suggest similar effects of snake venom. Death usually results from respiratory failure; such symptoms as lethargy, convulsive or twitching movements, and gasping respiration all are like those described above. It is particularly interesting to note that the secretion of the Gila monster causing symptoms so like those of snake bite comes from the sublabial gland, and is the only instance reported in reptiles of a toxic gland in the lower jaw.

The local reaction caused by a subcutaneous injection of *Blarina* poison in no way suggests the strong hemorrhagic effect of viperine venom. Although Pearson (1942, p. 160) mentions "considerable inflammation of the skin near the point of injection, and a subcutaneous accumulation of clear fluid", the pronounced swelling and discoloration of the tissues caused by the escape of blood from broken-down capillaries is not suggested. Authorities agree that such local reactions as are caused by cobra bite are slight as compared with viperine bite and are not especially painful. Calmette says the former is characterized by numbness, while Noguchi (1909, p. 110) says a "sensation of burning pain, more

or less severe, sets in at the seat of the bite. The spot soon becomes red, tender, and locally swollen." Compare these with Maynard's description (1889) of his reactions to the bite of a *Blarina* in which he says that within thirty seconds a burning sensation was felt in the immediate vicinity of the bites. This was intensified by shooting pains radiating from the minute punctures in all directions but particularly up the arm; parts immediately around the wounds became swollen and whitish, and the swelling spread to the rest of the hand reaching its maximum in about an hour. The swelling lasted for about three days and for about a week use of the injured hand caused shooting pains from the elbow downward. The lack of hemorrhagic symptoms suggests the effect of elapine venom, while the shooting pains suggest viperine. A Gila monster bite described by Shufeldt (1882) also caused him intense shooting pains up the arm and even down the corresponding side; these were followed by rapid swelling of the hand bitten; symptoms of shock are also mentioned.

Such notes as Pearson gives on the physical properties of the *Blarina* toxic extract show additional resemblances to snake venom. He says the former may be heated to 100°C. for 10 minutes without destroying its activity, that it is soluble in water and salt solution but not in acetone, and that it does not seem to be destroyed by drying. Elapine venoms may also be heated to 100°C. for a brief time without injury, whereas viperine venoms will not stand such high temperatures. All snake venoms are soluble in saline solution. Noguchi (1909, p. 102) says Ishizaka has found in *Bothrops flavoviridis*, a viperine snake, that "acetone separates out all active principles of the venom solution. The precipitate which is formed is difficultly [sic] soluble in water." All snake venoms may be dried at ordinary temperatures without losing their toxicity.

Of particular interest is the question of just how a toxic saliva is useful to *Blarina*. Pearson has already suggested its value in helping to overcome large prey. In this connection descriptions by Hamilton (1930) and by Shull (1907) of *Blarina* biting mice through the skull are interesting. Such an attack would certainly inoculate a neurotoxic poison where it could take rapid effect, if not in lethal doses, at least in doses sufficiently large to be of material assistance to the shrew. It is further possible, in view of the proportionally few large animals that *Blarina* regularly eats, that a more important use of such a poison would be to render sluggish such snails, earthworms, or beetles as have been found alive in storage chambers, so that the shrew would not have to depend entirely on various forms of mutilation to immobilize its prey. The eight snails and two slugs which Ingram (1943) found alive in a storage chamber were, as he says in a letter (Aug. 27, 1944), "not apparently injured; . . . I noted primarily that their shells were intact. I did not attempt to pull the individuals out of the shells . . ."

It has long been known that venom is useful to snakes primarily in helping them to overcome their prey and also in defense. More recently it has been discovered that this secretion of the parotid glands has a digestive function. Certain ferment-like substances are present in venom in varying amounts. Among them is a strong proteolytic ferment capable of completely disintegrating muscle tissue in a very short time. Various facts suggest that such a substance may also be

present in the secretions of the submaxillary gland in *Blarina*. Anyone who has trapped shrews has found that they have to be skinned almost immediately to prevent the hair on the belly from slipping. If left for any length of time, the whole ventral body wall seems to dissolve away. It is also true that *Blarina* is able to eat and digest unusually large quantities of protein food. Certain authors have claimed that they eat two or three times their own weight daily while Hamilton says that half the animal's weight in food is sufficient over a 24 hour period. Even the latter amount is large and presumably would call for very powerful digestive juices which might easily come, in part, from the saliva, particularly when the food is well chewed. In this connection, Hamilton says (1930, p. 26) "More often than not the food is so well chewed that it is a difficult matter to determine what has been eaten", and (*op. cit.*, p. 34) "Small slugs and sowbugs were taken into the mouth entire, but chewed well."

All the evidence available on the effect of *Blarina* poison and of reptile venom, particularly that of the cobra, suggests very strongly that these salivary secretions resemble each other closely. Since snake venom is known to have a strong digestive action on protein, it is further suggested that *Blarina* saliva, in contrast to that of other mammals, may also have this property.

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THE SPRING MOLT OF THE NORTHERN RED SQUIRREL IN MINNESOTA

By Bernard A. Nelson

This paper is based on the study of a large series of red squirrel skins (*Tamiasciurus hudsonicus*) in the Economic Zoology museum collection at University Farm, St. Paul. Additional material was available at the Museum of Natural History, University of Minnesota. The study of museum specimens was supplemented by observations made from April 1 to September 9, 1943, of the molt of a captive red squirrel.

The skins studied were collected at the Cloquet Forest Experiment Station, a relatively small area located in east-central Minnesota, about 15 miles west of Duluth. The captive squirrel was obtained from the same area. Of the 108 specimens in the series, 2 were taken in 1934, 8 in 1935, 81 in 1936, 4 in 1937 and 2 in 1941. The year of collection for 11 of the specimens is unknown, but from the condition of the pelage and the data given on the labels of some of them, they apparently are all spring or early summer skins. The 1936 series consisted of 39 April specimens, 40 May specimens and 2 June specimens; the other study skins are taken in spring or early summer except for 3, which were taken in August and September of 1934 and 1935. Although somewhat deficient in specimens showing the later stages of molt, the material was ample to show the sequence of the spring molt.

Coincident with this study, a total of 180 skins were examined in an attempt to work out the taxonomy and distribution of red squirrels in the state. It was apparent from the literature reviewed that considerable confusion exists regarding the taxonomy of *Tamiasciurus* in Minnesota. Hatfield (1938) lists three subspecies for the state, but from the ranges given it is not clear which of the three occurs in the Cloquet area. My work led me to believe that the Cloquet specimens represent intergrading forms between typical *hudsonicus* and a southern subspecies, either *loquax* or *minnesota*, as suggested by Cory (1912). I have classified them as *Tamiasciurus h. hudsonicus*, to which form they seem more referrable.

A detailed description of the northern red squirrel is unnecessary here. The general aspects of the winter and summer pelage are given below.

Winter.—Above with a rufous band extending from the tail to a point just forward of the ears; sides and outer limbs and feet yellowish gray with black peppering; underparts grayish-white, more or less vermiculated with black; head dark above, gray on sides becoming buff about the nose.

Summer.—General coloration darker; red dorsal band absent; sides and back dark olivaceous gray; limbs and feet ochraceous to reddish ochraceous; underparts pure white; black lateral line separating the underparts and the sides.

THE SPRING MOLT

Red squirrels molt twice a year, a process involving a change in color and a complete change of pelage. In the Cloquet series of 1936, the earliest date at

which signs of the spring molt were evident was April 6, while in one specimen the molt had not progressed beyond the head by as late as May 29. Another specimen taken on May 18 had not begun the spring molt. There may be as much as 40 or 50 days difference in the onset of the pelage change. Although the time at which the molt began varied greatly among individuals, most of the specimens were in the process of molting by the middle of May.

The first changes occur either around the nose and under the chin, or on the front feet; or the molt may begin at these two places at about the same time. The molt begins later on the hind feet, but usually before much change has occurred on the back. On the front feet the molt commonly proceeds faster on the inner side of the feet, many specimens showing the ochraceous summer coat to the heel on the inside while on the outside of the feet the winter coat persists almost to the end of the toes. A similar unevenness in the appearance of the summer coat is seen on the hind feet, but either side of the foot may change color first. In the early stages, the molt frequently begins on a single row of phalanges of the hind foot first, usually the second row from the claws, while the distal row remains unchanged. The sides of the head ordinarily assume the summer pelage before the top of the head. The molt is also complete along the flanks and on the underparts before the back has changed pelage completely. The molt on the back is often ragged and irregular, with the rump retaining the winter coat the longest.

The red squirrel captured alive at Cloquet and kept in a cage at University Farm had begun molting by April 1, when the feet were partially in summer pelage. Another squirrel captured at the same time and place showed no signs of molting. A week later the feet were still in winter coat, but the molt had just started about the nose. On April 9 it escaped, preventing further observations. On April 8, the other squirrel was in summer pelage on the front feet and two-thirds of the way from the toes to the heels of the hind feet, while the molt was just starting around the nose. On April 18, the molt had progressed to the heels of the hind feet with little change elsewhere. On April 20, a bare spot was noticed on the back between the shoulders. The skin had been scratched and since the squirrel had a habit of crawling under the wire partitions of the cage, this bare spot was probably caused by the wire, although the molt may have been partially responsible. By May 5, summer pelage was growing in on the bare spot, and the molt had started under the chin and had advanced to the elbow of the front legs, but was not complete on the hind feet, being further advanced on the outside than on the inside. Not much change had occurred by May 20, the summer coat having advanced about half way to the eyes on the top of the head, and from the nose to the eyes in a strip along the side of the head. The area on the back was slightly larger. By May 27, the molt had progressed almost to the eyes on the top of the head, and the patch on the back was almost midway between shoulders and rump. On June 3, the summer coat was halfway between the eyes and ears on top of the head, and the strip on the side of the head had advanced to the base of the ears. The area on the back had extended to the sides of the body; the molt was complete on the hind feet; and most of the underside of the head was in summer pelage.

On June 10, the summer coat had advanced from the nose to the ears except for a portion in the middle which extended one-third the distance from the ears to the eyes. The ochraceous summer coat had begun to show on the anterior outer side of the front legs, and had spread a short distance above the heels on the hind legs. There was a small patch of the white summer coat between the front legs on the under side and a similar strip across the chest which extended onto the upper shoulder where it became ochraceous. The patch of summer pelage on the back had advanced toward the head.

On June 14, the head was in complete summer pelage except for a narrow strip around the neck which extended between the ears and over the head in a V. The summer pelage on the outer side of the shoulders had almost joined with the summer pelage of the back; the summer pelage had advanced over the front margin of the shoulders and met with the summer pelage of the neck and under part of the chin. The molt was almost complete on the chest, and a strip of summer pelage extended from between the front legs to the middle of the belly. On the back the summer coat had advanced to within 2 inches of the tail, and a small patch of summer pelage had appeared about one inch from the base of the tail. The hind legs were in summer pelage to slightly above the knees, and a small new patch appeared on the hips. The lateral line had not as yet become apparent.

On June 25, winter pelage was still present on the back to a point 1½ inches anterior of the base of the tail and extended forward along the upper part of the sides to the shoulder. The upper half of the thighs were still in winter pelage, and a small area of winter pelage remained on the lower part of the thigh. The anterior portion of the underparts was in summer pelage, extending as far back as the front edge of the hips where it narrowed and extended in a narrow strip to the penis. The summer pelage had advanced dorsally about half way up the flanks, ending at the lateral line which had appeared by this time.

By July 1, the summer pelage had progressed in a very narrow strip almost to the tail on the back; the underparts were in complete summer pelage except for the area posterior to the penis; a small patch of winter pelage remained on one flank; the upper part of the hind legs were in winter pelage which extended over the rump to the mid-dorsal strip of summer pelage; and small tufts of the winter coat remained above the heels, at the hind margin of the elbow, and on the inner surface of the hind legs.

On July 9, winter pelage remained only on the posterior and lateral parts of the rump, in a strip from the penis to the base of the tail on the underside, in tufts above the heels, on the anterior edge of the thighs, and on the posterior part of the elbows.

By July 17, only a half-inch strip over the rump and a few tufts above the heels were in winter pelage. On July 28, the summer coat was complete except for the extreme posterior sides of the rump which still showed some of the ragged winter pelage. On August 14, the squirrel was in complete summer pelage. Observations were made on August 28, September 9, and November 6, on which date the animal died. At this time it was still in the full summer pelage. The time required for completion of the spring molt was between 120 and 135 days.

The black lateral line, characteristic of the summer pelage, varied in sharpness and the clearness of the black in the specimens studied. Allen (1890), in a paper on the seasonal variations in color in *Tamiasciurus hudsonicus*, states that the intensity of the lateral line reaches its height in September and October. Hatt (1929) says the same thing of *T. h. gymnicus* and *T. h. loquax*. This would seem to imply either a change in the pigmentation of the hairs or a growth of more black hairs to increase the intensity of the black line. In the Minnesota specimens examined, no well defined increase in the intensity and distinctness of the lateral line from spring to fall was observed. Of the four specimens which showed the most distinct lateral line, one was taken in May, two in July, and one in October. Those in which the lateral line was indistinct included skins taken in May, June, July, August, and September. The lateral line became apparent in the pelage of the captive squirrel between June 14 and June 25 and showed some increase in intensity as the molt progressed until the sides were in complete summer pelage in the first week of July. Observations made after that showed no increase in the intensity of the black line.

Variation in the intensity of the black line appeared to depend on the amount of yellow in the hairs. When the line was quite distinct, the hairs were mostly black, although many had a yellow ring which varied in position from near the tip to about two-thirds of the way to the base of the hair. Skins having an indefinite lateral line were found to have many of the black hairs ringed with two yellow bands, one near the tip and the other toward the base of the hair. They resembled the hairs of the flank in the winter coat. An increase in intensity in the black line would require the loss of the double ringed hairs, or a spread of pigmentation in the hairs so that they would be entirely black or have but one yellow ring.

Although only a few late fall and early winter specimens were studied, they indicate that the fall molt takes place in the opposite order from the spring molt, the winter pelage appearing first on the rump and back, and last on the feet and head.

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THE MEXICAN VOLCANO MOUSE, NEOTOMODON

By William B. Davis and Lewis A. Follansbee

In the nearly 50 years that have elapsed since Merriam (1898) described as *Neotomodon alstoni*, *N. orizabae*, and *N. perotensis* the unique mice collected by E. W. Nelson and E. A. Goldman on the higher mountains of the Mexican Plateau, little information on their habits and relationships has appeared in print. Miller and Rehn (1901) listed the three species, placing them in the subfamily Neotominae. Goldman (1910) considered *Neotomodon* too aberrant to be included with the wood rats in the Neotominae and concluded that the genus belongs nearer the Cricetinae, along with *Peromyscus* and related forms. Davis (1944) considered all three "species" conspecific and recognized but two geographic races, *Neotomodon alstoni alstoni* and *N. a. perotensis; N. orizabae* was placed as a synonymy of *N. a. perotensis*. He did not present evidence supporting his conclusions, however. The purpose of this paper is to present that evidence and also to place on record the available information on the life history and ecology of this relatively little known mouse.

The bases for this report are the study of more than 100 conventional study skins with skulls, several alcoholics, and the field notes and observations of both authors (see Davis, *op. cit.*). Follansbee began the study independently in 1942 at the suggestion of Davis, but never completed it because of exigencies arising from the War.

For the loan of comparative material, and a perusal of the literature pertaining to *Neotomodon*, we thank Dr. H. H. T. Jackson, U. S. Fish and Wildlife Service.

HABITS

Habitat.—So far as known, this genus is restricted to the high volcanic mountains in the Mexican states of Michoacan, México, Morelos, Pueblo, and Veracruz. It occupies an altitudinal range from 8,500 feet (Nahuatzin, Michoacan) to near timberline at 14,000 feet (on Mt. Popocatepetl). At the lower elevations, the dominant vegetation is a mixed forest of pines and oaks, but higher up the forest changes to mixed stands of pines and firs, and culminates, near timberline, in nearly pure stands of pines. These trees seem to be but a secondary adjunct in the immediate welfare of the mice, however; the understory of tall, dense, stiff-bladed, bunch grass, locally known as "sacaton" to distinguish it from "sacate", the Mexican term for other grasses, is a prime requisite. In this tall, rank vegetation, *Neotomodon* abounds, along with a number of other small mammals.

We found *Neotomodon* in all vegetation belts occupied by sacaton, but in any one given area it did not occupy all such belts. It was occasionally present in one or two, but absent from the belt or belts above or below. Thus, on the sides of Cofre de Perote it was present in the lower pine-fir transition but was absent from the nearly pure pine forest at timberline. It was not present in the lower pine belt on Mt. Orizaba, but was fairly common in the mixed pine-fir forest at

11,000 feet and above. More or less open mixed stands of pines and firs where the intervening openings were covered with sacaton supported the heaviest populations. Both above and below this belt the population decreased, with the lowest population in pure stands of firs.

Burrows.—Attempts were made to study the burrow systems. There was no absolute method of determining ownership of a burrow beforehand because *Peromyscus melanotis* and *Neotomodon* occurred in the same vicinity. *Neotomodon* is somewhat larger than *P. melanotis* so the larger burrows were opened with the thought that they might belong to it. Whether this method was accurate could not be ascertained because of 13 burrows studied only 2 contained occupants. One of these was captured and proved to be *Neotomodon;* the other was not, but it was thought to be. The only other mouse in the area with which it could have been confused was *Peromyscus melanotis*, but, because of the larger size of the mouse we saw, we feel confident that it, too, was *Neotomodon.*

The 11 other burrows showed signs of recent occupancy. No nests were found, although pregnant females were trapped in the vicinity during this particular phase of the study. The shortest complete burrow was 19 inches in length, the longest 67 inches. Of the 13 burrows opened only 8 could be followed to the end. The other 5 disappeared beneath volcanic boulders too large to be overturned or moved.

The burrows were located on well-drained sites, were of simple design, and about 50 mm in diameter. The openings were usually partly concealed by vegetation. No mounds of earth were detected. We have reason to believe that abandoned burrows of the small pocket gopher, *Thomomys umbrinus*, also are utilized by *Neotomodon.*

Runways.—No distinct runways such as *Sigmodon* and *Microtus* utilize were detected. The nature of the vegetation in which *Neotomodon* lives obviates their use. The sacaton grows in clumps, the bases of which are spaced from 3 to 12 inches, or more, apart, and the tops fan out to provide a nearly complete canopy.

Activity.—Insofar as we could determine, *Neotomodon* is most active early at night. Traplines set in mid-afternoon were undisturbed except by an occasional junco or striped ground sparrow. *Peromyscus melanotis* were first to enter the traps in the evening, and it was not until well after dark that *Neotomodon* were caught. If all *Neotomodon* were removed between 9 and 10 p.m., a few additional individuals were usually caught between then and midnight; if all were removed before midnight, very few were in our traps next morning.

The following record of a trapline at our camp at 10,500 feet on Cofre de Perote in late July gives some idea of relative activity and abundance of *Neotomodon* as compared with *Peromyscus melanotis.* We believe that the disturbance caused by our moving about with a flashlight was negligible. On one occasion a *Peromyscus melanotis*, frightened away by our flashing the light on it, returned in a few seconds after the light was turned off.

6:00 p.m. 30 traps set along a creek bank
6:49 p.m. 3 *P. melanotis*, traps reset
7:10 p.m. 5 " " " "

7:25 p.m.	3	*P. melanotis*,	traps	reset	
7:40 p.m.	1 "	"	2	*Neotomodon*,	reset
8:10 p.m.	3 "	"	3	"	"
8:45 p.m.	4 "	"	2	"	"
9:00 p.m.	3 "	"	1	"	"
9:30 p.m.	5 "	"	1	"	"
11:00 p.m.	3 "	"	0	"	(not removed)
5:50 a.m.	9 "	"	1	"	

These 30 traps yielded a total catch of 49 individuals that night, 10 of which were *Neotomodon*. The majority of the *Neotomodon* were caught between 8 p.m. and 9 p.m.; only one was caught between 11 p.m. and morning. Another check on August 3 gave similar results.

Home Range.—Live-traps were used in an attempt to determine the home range of *Neotomodon*. A total of 54 trap-nights was run on Mt. Popocatepetl and 36 on Cofre de Perote with the following results: In the 9 traps set the first night on Mt. Popocatepetl no *Neotomodon* were caught. The second night only one was taken, but it was dead when removed from the trap. On the four other nights 6 *Peromyscus melanotis*, 2 *Reithrodontomys chrysopsis*, and a second *Neotomodon* were captured.

On Cofre de Perote our results were better, but even so we learned little. Of seven *Neotomodon* captured, four were transferred to holding cages, and three were toe-marked and released at the site of capture. Only one was recaptured. It was retaken within 20 feet of the point where it was first captured and released.

The attempt to determine the home range of *Neotomodon* was wholly unsatisfactory. If the same amount of time had been spent on a study of *Peromyscus melanotis*, the results probably would have been more enlightening because this mouse was much more common and continually fouled our traps. To assure any degree of success in further studies of this phase of the ecology of *Neotomodon*, we recommend the previous removal of the ubiquitous *Peromyscus melanotis*.

Breeding.—Our data are far from complete, partly because they do not cover all of the breeding period. Breeding begins earlier than June 23 and terminates some time after August 19. Adult males taken throughout that period had enlarged testes, measuring from 10 x 7 mm to 18 x 7 mm. That the end of the breeding season was close at hand in mid-August was suggested by the capture on August 16 of an old male (worn teeth) whose testes were recorded as "small".

Pregnancy records are given in Table 1. From these data we were unable to detect any peaks, nor could we estimate the length of the period of gestation.

Nearly full-grown young were captured as early in the season as July 14. On that date a female in "black" juvenal pelage and weighing 46.4 grams (non-pregnant adult females weighed about 52 grams) was captured. That by July 28 some young-of-the-year had matured sexually is evidenced by the capture on that date of a young male in "black" pelage and weighing 42.7 grams whose testes measured 12 x 7 mm, and by the capture on July 31 of a young female, weighing 40.9 grams, that contained four embryos 8 mm in crown-rump length.

These data prove that young of early litters mature sexually and may produce litters themselves within the seasonal breeding period of the species.

Weights.—In general, adult females outweighed adult males by several grams, although considerable individual variation occurred. Adult males of *alstoni* averaged 48.2 grams, ranging from 43 to 55 grams. Non-pregnant females of *alstoni* weighed from 48.1 grams to 61.5 grams, averaging 53.2 grams; pregnant females ranged from 57.7 grams to 65.8 grams, averaging 63.6 grams.

Individuals of *perotensis* were, in general, lighter in weight than those of *alstoni* of similar age, sex, and physical condition. Adult males ranged from 36.7 grams (old individual with much worn teeth) to 46.5 grams, averaging 42.8 grams; adult non-pregnant females averaged 43 grams; pregnant females averaged 48.3 (40.9–52.9) grams.

TABLE 1.—*Pregnancy Records in Neotomodon*

DATE	NUMBER OF EMBRYOS	CROWN-RUMP LENGTH (mm)	REMARKS
June 25	3	"minute"	Probably less than 3 mm
" 27	3	10	
July 5	—	—	Lactating; had given birth to four young.
" 20	3	20	
" 22	3	5	
" 22	5	25	
" 31	4	8	A young female of an earlier litter; still retained some juvenal pelage.
" 31	4	8	
Aug. 1	4	2	
" 1	2	11	
" 4	4	3	
" 15	4	1	
" 15	2	2	
Average...	3.4		

Animal associates.—Living in the same habitat, and often captured in the same trap lines, were other small mammals such as the ubiquitous *Peromyscus melanotis* and the rare *Reithrodontomys chrysopsis*, mentioned above; others were the pygmy volcano rabbit, *Romerolagus diazi;* two cottontails, *Sylvilagus floridanus orizabae* and *Sylvilagus cunicularis cunicularis;* a meadow mouse, *Microtus mexicanus mexicanus;* a cotton rat, *Sigmodon alticola amoles;* two shrews, *Sorex saussurei saussurei* and *Cryptotis alticola;* and, at the lower altitudinal range of the species, two wood mice, *Peromyscus boylii levipes* and *Peromyscus maniculatus labecula* and a second harvest mouse, *Reithrodontomys megalotis saturatus.* Most of these mammalian associates probably compete to some degree with *Neotomodon*, but the effects are not serious as judged from our trapline records. Next to *Peromyscus melanotis*, *Neotomodon* was the most abundant small mammal in the areas under consideration.

SYSTEMATICS

Position of the Genus.—Considerable uncertainty exists as to the relationships of *Neotomodon* with other Cricetidae. Merriam (*op. cit.*) refers to it as "murine" and in general appearance "intermediate between *Microtus* and *Peromyscus* of the *guatemalensis* group." Miller and Rhen (1901) place it in the subfamily Neotominae, along with *Neotoma*, *Nelsonia*, *Xenomys*, and *Hodomys*. Goldman (1910), however, concluded that it is not closely allied to the wood rats (Neotominae), but rather that its affinities lie with the Cricetinae. Miller (1924) places it between *Sigmodon* and *Neotoma*, each of which is assigned to a different subfamily. Ellerman (1941) apparently follows Miller.

The molariform teeth of *Neotomodon* were said by Merriam (*op. cit.*) to resemble those of *Neotoma*, which fact influenced his choice of name for the genus.

TABLE 2.—*Comparison of molars in three genera of cricetid rodents*

NEOTOMA	NEOTOMODON	PEROMYSCUS
Enamel loops produced into sharp, angular projections.	Enamel loops in general rounded, not sharp.	Enamel loops usually rounded, not sharp.
Reentrant angles wide, open, V-shaped.	Reentrant angles with sides parallel, decidedly not V-shaped.	Reentrant angles with sides parallel, rarely V-shaped.
General appearance of tooth not compact but of open construction.	General appearance compact, approaching that of *Peromyscus*.	General appearance compact, dense, of sturdy construction.
M^3 never a mere peg, resembles M^1 and M^2.	M^3 a peg, with wear producing an enamel "island".	M^3 a peg, with wear producing an enamel "island".
Third lower molar "H" shaped.	Third lower molar "S-" shaped in young, roughly like figure 6 in adults.	Third lower molar roughly "S-" shaped.

Our study leads us to conclude that on the basis of general shape of skull, dental characters, and habits, *Neotomodon* is much closer to *Peromyscus* than to any other Recent genus. Table 2 compares some of the features of the molars of *Neotoma*, *Neotomodon*, and *Peromyscus*.

Teeth of young.—M^1: This molar is characterized by three salient enamel loops and two reentrant angles on both side, the first pair of reentrant angles being opposite; in the second pair the outer is posterior to the inner. The outer reentrant angles are much deeper than the inner; the inner anterior angle is smallest and shallowest. The anterior salient loops are opposite each other, the outer being the larger and the inner reduced so that it is apparent only in young specimens. A shallow groove (not a reentrant angle) is apparent on the anterior face of the tooth, but this disappears with a small amount of wear.

M^2: There are three salient enamel loops and two reentrant angles on the

outer side and two salient loops and a single reentrant angle on the inner side. None of the reentrant angles is directly opposite another; the inner reentrant angle is opposite the middle outer salient loop.

M^3: This molar is essentially a rounded peg, about one-half the size of the first and second molars. In a tooth just emerging, a shallow groove on the inner side is all that interrupts the otherwise smooth surface.

M_1: In this tooth there are four salient loops and three reentrant angles on the inner side, the anterior one smallest; on the outer side, three salient loops and two reentrant angles. The anterior loops and angles are opposite each other; those following alternate.

M_2: This molar has three salient loops and two reentrant angles on both sides. It differs from the second upper molar in having three, rather than two, loops, and two, rather than one, reentrant angles on the inner side.

M_3: This tooth resembles the letter "S" ("S" on left side, reverse "S" on right side), with a single reentrant angle on each side. On the outer side are two nearly equal gently rounded loops separated by a generous reentrant angle. On the inner side are a broad posterior and a narrow, more acute, anterior salient loop. The reentrant angle is approximately one-fourth the distance from the anterior face of the tooth.

Teeth of subadults.—The appearance of the teeth is in general like that of the young. The occlusal surfaces of the last molars (M^3 and M_3) are now flush with the others. Little wear is apparent in the second molars until the last molars are fully developed. The first molars begin to show some wear while the last molars are developing. The outer portions of the salient enamel loops are produced into sharp sheer-like edges. It is at this stage that the teeth appear to be sharpest and most efficient.

Teeth of adults.—At this stage the teeth show marked differences from those of the young and sub-adults. In an aged individual the enamel pattern, as seen from the crown, is considerably altered. Merriam (1998) says that M^1 and M^2 show the most pronounced signs of wear and M_3 the least. In the series of skulls examined by us, it was difficult to determine that M_3 wore any less rapidly than others. In all instances the crown of a well worn tooth is composed of a high percentage of dentine.

M^1: The anterior reentrant angle on the inner side is the first to disappear. With additional wear the anterior angle on the outer side is obliterated, leaving the posterior pair to persist.

M^2: The outer anterior reentrant angle is the first to disappear. It frequently persists, however, as an oblong "island" in some teeth. The inner posterior reenterant angle is the next to be obliterated, thus leaving the posterior reentrant angle on the outer side as the last indication of the original three (except when the "island" described above persists).

M^3: In a well-worn tooth there are two enamel rings, one inside the other, the inner (oval) separated from the outer (irregular) by a ring of dentine. The inner is not concentric with the outer as the axes are not in the same plane.

M_1: The outer anterior reentrant angle is obliterated first, leaving the well-

defined posterior reentrant angle. On the inner side, only the second of the original three reentrant angles persists. The shallow first reentrant angle disappears with moderate wear and the posterior one remains for a short time as an "island", but soon disappears.

M_2: The outer anterior reentrant angle is obliterated, leaving only the posterior one. On the inner side the anterior reentrant angle persists; the posterior one is obliterated with moderate wear. In both M_1 and M_2 the resultant enamel pattern resembles, as suggested by Merriam (1898), . . ."two large lobes not unlike a figure eight turned sideways."

M_3: The reentrant angle on the inner side is the first to disappear. The outer angle persists.

Status of the species.—The methods of study employed by us were essentially those outlined by Hall and Hoffmeister (1942) in their study of the geographic variation of *Peromyscus crinitus*. All specimens were segregated first on the basis of locality. Within each such geographic group, individuals were further segregated by sex, and each sex by age. Cranial measurements were made of the adults in each such group, the criterion of maturity being an appreciable amount of wear on the molar teeth. Measurements were tabulated to facilitate comparison within and among groups in order to determine the degree of individual and geographic variation in cranial characters. Cranial measurements were relied upon more heavily than external measurements for two reasons. First, all collectors did not take their measurements with the same degree of accuracy. Second, as Goin (1943) points out, measurements of total length and length of tail vertebrae of specimens made into study skins are subject to 5 per cent error even in the hands of experienced preparators and that in a given population of mammals these two measurements may vary naturally in excess of 5 per cent. A total error in excess of 10 per cent, therefore, is frequently inescapable.

Height of ear from the notch and length of hind foot were considered by Goin to be more reliable than total length and length of tail vertebrae, the reliability (from greatest to least) being in the following order: length of hind foot, height of ear, length of tail vertebrae, and total length. Second to cranial measurements, we have relied upon length of hind foot in arriving at our conclusions.

Merriam (*op. cit.*) had access to 57 specimens of *Neotomodon*, the study of which led him to conclude that those individuals from west of the valley of the Rió Balsas were assignable to one species, *N. alstoni;* those from Mount Orizaba to *N. orizaba* and those from the Cofre de Perote to *N. perotensis*. In separating *alstoni* from *perotensis* and *orizabae*, he states, (p. 128): "Compared with both of the other known species of the genus, *perotensis* and *orizabae*, the skull [of *alstoni*] is *longer* and *heavier*, and when old much more angular (italics ours)". In commenting on *perotensis*, he states (p. 129) that the "skull is similar to that of *alstoni*, but slightly *smaller*, and in old age not becoming so *angular*" (italics ours). In describing *orizabae*, he points out that the "skull is like that of *perotensis*, but *smaller* and *weaker* (italics ours)." Our measurements (Tables 5 and 6) show no such constant geographic variation; in fact, any given character

TABLE 3.—*Average and Extreme External Measurements (in millimeters) of adult males of Neotomodon*

LOCALITY	TOTAL LENGTH	TAIL VERTEBRAE	HIND FOOT	EAR, FROM NOTCH	NUMBER AVERAGED
Nahuatzin, Michoacan	219 (218–222)	102 (99–104)	26 (25.5–26.5)	—	3
Toluca Valley, México	217.5 (215–220)	96.5 (94–97)	26.5 (26–27)	—	2
Mt. Popocatapetl, México	213 (207–219)	91 (85–94)	25.7 (25–26)	22.0 (21–23)	3
Río Frío, México	198.7 (179–220)	89.3 (80–104)	25.3 (24–26)	20.1 (19–22)	11
Río Otlati, Puebla	206 (205–207)	87.5 (85–90)	25.0 (25–25)	20.5 (20–21)	2
Cofre de Perote, Veracruz	202.7 (193–209)	91.1 (89–97)	24.8 (23–26)	21.1 (20–22)	7
Mt. Orizaba, Puebla	186.4 (180–194)	75.2 (78–88)	23.8 (23–25)	21.0 (21–21)	5

TABLE 4.—*Average and Extreme External Measurements (in millimeters) of adult females of Neotomodon*

LOCALITY	TOTAL LENGTH	TAIL VERTEBRAE	HIND FOOT	EAR, FROM NOTCH	NUMBER AVERAGED
Nahuatzin, Michoacan	—	—	—	—	—
Toluca Valley, México	209.7 (205–216)	87.0 (78–98)	25.2 (24–26)	—	4
Mt. Popocatapetl, México	205.2 (200–210)	93.5 (91–97)	24.7 (24–25)	22.0 (22–23)	4
Río Frío, México	208.6 (202–220)	92.0 (90–95)	24.5 (23–27)	21.6 (20–22)	6
Río Otlati, Puebla	221.2 (205–233)	96.6 (85–105)	25.0 (24–26)	20.6 (20–22)	5
Cofre de Perote, Veracruz	198.0 (194–210)	90.0 (89–92)	24.1 (23–26)	21.3 (20–22)	6
Mt. Orizaba, Puebla	186.6 (176–198)	86.3 (80–97)	24.3 (24–25)	20.0 (20–21)	3

seems to vary independently. Certainly we could find no basis for such designations as larger, heavier; smaller, weaker; and more angular, not so angular in

the specimens available to us. It is difficult to select skulls from each of the three areas to which Merriam restricted his "species" without finding an overlap of characters.

We grant that selected skulls vary appreciably from one population to another. But individual variation within a single population obliterates any geographic variation present to such an extent that, on the basis of cranial characters alone, the three populations are inseparable specifically if one adheres to the criterion of "no overlap in character" or "trenchant difference". Cranial measurements

TABLE 5.—*Cranial Measurements (in millimeters) of adult males of Neotomodon*

LOCALITY	CONDYLO-BASAL LENGTH	ZYGOMATIC BREADTH	MASTOID BREADTH	LENGTH OF NASALS	PALATILAR LENGTH	POST-PALATAL LENGTH	LENGTH OF MAXILLARY TOOTH ROW	NUMBER AVERAGED
Nahuatzin, Michoacan	28.5	15.4	13.0	12.2	13.7	10.7	5.3	3
	(28.5–28.6)	(15.2–15.7)	(12.9–13.2)	(11.7–12.6)	(13.6–13.8)	(10.4–10.9)	(5.1–5.5)	
Toluca Valley, México	27.5	15.5	12.9	12.1	13.3	10.5	5.2	2
	(27.4–27.6)	(15.4–15.6)	(12.8–13.0)	(11.7–12.6)	(13.2–13.4)	(10.4–10.7)	(5.2–5.3)	
Mt. Popocatapetl, México	28.3	15.6	13.2	13.2	13.8	10.9	5.4	3
	(27.5–29.4)	(15.4–15.8)	(13.1–13.5)	(13.0–13.7)	(13.7–14.0)	(10.9–10.9)	(5.3–5.5)	
Río Frío, México	27.6	15.7	12.9	12.5	13.5	10.9	5.2	11
	(26.8–28.2)	(15.1–16.0)	(12.3–13.4)	(11.5–13.6)	(12.9–13.8)	(10.0–11.7)	(5.0–5.5)	
Río Otlati, Puebla	28.0	16.0	12.8	12.4	13.5	10.7	5.2	2
	(28.0–28.0)	(15.7–16.4)	(12.7–13.0)	(12.2–12.7)	(13.4–13.6)	(10.7–10.7)	(5.1–5.3)	
Cofre de Perote, Veracruz	27.5	15.4	12.8	12.2	13.3	10.7	5.2	9
	(26.9–28.1)	(14.8–16.0)	(12.2–13.0)	(11.1–12.6)	(13.0–13.5)	(10.2–11.2)	(5.1–5.5)	
Mt. Orizaba, Puebla	27.7	15.5	12.8	12.6	13.4	10.7	5.1	4
	(27.6–27.9)	(15.0–15.6)	(12.7–12.8)	(12.4–13.0)	(13.2–13.8)	(10.6–10.7)	(5.0–5.3)	

of specimens available to us (see Tables 5 and 6) bear this out. In females from Toluca Valley (from the center of the range of *alstoni*), for example, the condylobasal length averages 27.3 (27.1–27.7) mm as compared with 27.7 (27.2–28.2) mm in specimens of the same sex from Cofre de Perote, and with 27.5 (27.1–27.8) mm in those from Mount Orizaba. The zygomatic breadth in the three populations, in the same sequences, is 15.2 (15.1–15.4); 15.7 (15.2–15.9); 15.0 (14.7–15.3); mastoid breadth, 13.0 (12.7–13.4); 12.9 (12.8–13.2); 12.8 (12.7–12.9). The length of the maxillary tooth row averages 5.1 mm in each of the three populations.

During the study, it became apparent that the present discontinuous distribution of the genus argues against considering the three "species" conspecific. External characterstics do indicate some degree of geographic differation. In external measurements, there are recognizable differences between specimens trapped in the Orizaba—Cofre de Perote area and those from west of the Rió Balsas (Rió Otlati, Monte Río Frío, Mount Popocatepetl, and Laguna Zempoala). Length of the hind foot of both sexes shows no constant differences, although males from Mount Orizaba average slightly smaller than those from other localities; likewise the tail vertebrae of both males and females from

TABLE 6.—*Cranial Measurements (in millimeters) of adult females of Neotomodon*

LOCALITY	CONDYLO-BASAL LENGTH	ZYGOMATIC BREADTH	MASTOID BREADTH	LENGTH OF NASALS	PALATILAR LENGTH	POST-PALATAL LENGTH	LENGTH OF MAXILLARY TOOTH ROW	NUMBER AVERAGED
Nahuatzin, Michoacan	—	—	—	—	—	—	—	—
Toluca Valley, México	27.3 (27.1–27.7)	15.2 (17.1–15.4)	13.0 (12.7–13.4)	12.1 (11.6–12.4)	13.1 (13.0–13.3)	10.2 (10.0–10.8)	5.1 (5.1–5.2)	4
Mt. Popocatapetl, México	28.3 (28.1–28.5)	15.6 (15.2–15.9)	13.1 (12.9–13.5)	13.0 (13.0–13.1)	13.6 (13.5–13.8)	10.9 (10.7–11.2)	5.4 (5.2–5.5)	3
Río Frío, México	28.5 (28.0–29.0)	15.9 (15.6–16.7)	13.1 (12.7–13.6)	12.7 (12.1–13.2)	13.7 (13.5–14.1)	10.8 (10.5–11.1)	5.3 (5.1–5.6)	5
Río Otlati, Puebla	28.6 (28.2–29.1)	16.2 (15.9–16.5)	13.0 (12.8–13.3)	12.9 (12.4–13.7)	13.6 (13.0–13.9)	11.0 (10.4–11.8)	5.3 (5.0–5.7)	5
Cofre de Perote, Veracruz	27.7 (27.2–28.2)	15.7 (15.2–15.9)	12.9 (12.8–13.2)	12.6 (12.1–12.7)	13.4 (13.1–13.7)	10.8 (10.7–11.1)	5.1 (4.9–5.4)	7
Mt. Orizaba, Puebla	27.5 (27.1–27.8)	15.0 (14.7–15.3)	12.8 (12.7–12.9)	12.1 (11.8–12.4)	13.2 (12.9–13.4)	10.4 (10.0–10.7)	5.1 (5.0–5.3)	2

Mount Orizaba average shorter. In total length, the difference is even more apparent; those from Mount Orizaba being smaller than all other populations studied; those from the type locality of *alstoni*, largest. In general, specimens from west of the Río Balsas are noticeably larger than those from localities to the east. This is further substantiated in the discussion of weight above. Of the two population samples from the eastern part of the range, the specimens from Mount Orazaba are noticeably smaller than those from Cofre de Perote. The mice from Cofre de Perote are intermediate, grading toward *alstoni*, although their closest affinity is clearly with the population to the south on Mt. Orizaba.

There is remarkable stability of color in the six populations studied (including a series of 3 topotypes from Nahuatizin, Michoacan, and a series of 6 skins from the upper end of the Valley of Toluca). The only important divergences are in the series from Laguna Zempoala, state of México, in which a tendency to darker coloration on the back, sides, and underparts is exhibited, and in the individuals from the Cofre de Perote—Orizaba region, which are slightly paler than mice from the other localities.

On the basis of the foregoing it seems necessary to merge the three supposed species into one, namely *alstoni*, and to recognize two geographic races, *alstoni* west of the Río Balsas) and *perotensis* (east of the Río Balsas in the Perote—Orizaba region). It would have been more appropriate to retain the name *orizabae*, because specimens from Mount Orizaba are more widely differentiated from *alstoni* than are those from the Cofre de Perote, but *perotensis* has priority so the name must stand.

SUMMARY

Neotomodon is much like *Peromyscus melanotis* in habits, living in close association with it and inhabiting grass-covered slopes on the high mountains of central Mexico. It appears to be strictly nocturnal and most active shortly after dark. Its burrows are of simple design, short and shallow. The breeding season extends at least from early June to September. Two or more litters, averaging 3.4 young each, are born each year and young-of-the-year may mature sexually and bear young the same season they themselves are born.

The mice appear, on the basis of cranial characters and habits, to be more closely related to *Peromyscus* than to any other Recent genus. One species, *Neotomodon alstoni*, is recognized, with two geographic races, *N. a. alstoni* and *N. a. perotensis*. *Neotomodon orizabae* is placed in the synonymy of *N. a. perotensis*.

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MORPHOLOGICAL CHARACTERS OF THE AUDITORY OSSICLES OF RECENT TALPIDAE

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In the course of a monographical study of the Talpidae, a number of puzzling systematical problems came to light, the solution of which required a detailed investigation of some morphological features usually ignored in the classification of mammals. Such was the case of the auditory ossicles, which, together with other morphological characters, supplied a secure basis for the classification of the family Talpidae. The present paper contains descriptions of the auditory ossicles of most of the representatives of the family Talpidae, based on a study of materials in the Zoological Institute of the Academy of Sciences of U.S.S.R.

The morphological characters of the auditory ossicles of the family Talpidae (as a whole) have not yet been described. Literature on this subject is but fragmentary. Doran (1876) in his more or less detailed description of the ear bones of different groups of mammals discusses the morphological characteristic of the ossicles of *Talpa*, *Condylura*, *Scalopus* and *Desmana*. Wilkie (1925, 1929) gives a detailed description of the auditory ossicles of *Talpa europaea* L.

Although the ear bones of different Talpidae exhibit definite morphological characters and may be easily classified, no previous attempt has been made to use them for the purpose of gaining an insight to questions of phylogenetic relations between groups of different taxonomic rank.

Usually characters of the dental system have been considered valid for the systematic differentiation of moles. Generally speaking, these features may well characterize the independence of certain genera and species; on the other hand, if inadequately interpreted by different authors, they lead to an artificial structure of the whole family. Even Thomas' (1912) latest attempt to classify the Talpidae, which gives only a list of subfamilies, is superficial and unnatural. The systematic relations between different subfamilies, genera and species remain unclear.

The ear bones of the Talpidae (malleus, incus and stapes) may be characterized by their well defined shape, which is subject to little variation. They present constant characters for the differentiation of subfamilies, genera and (in many instances) species, and for the study of the systematic relations of these groups. The differentiation of subfamilies within the family Talpidae, as based on the characters of their auditory ossicles, coincides closely with results based on all other morphological features combined.

The following features of structure of the auditory ossicles are typical of all Recent representatives of the family Talpidae. Malleus with a large, flattened lamina and a well developed head (capitulum mallei), with a broad articular surface for the incus. All other characters of the malleus are so peculiar in different groups of the family that it is impossible to give them a generalized description. Processus brevis incudis is always poorly developed. Processus longus incudis, on its median surface, bears a more or less distinguishable groove. The stapes may be characterized by strongly divergent crura.

SUBFAMILY TALPINAE

The auditory ossicles of the subfamily Talpinae (Plates 1 and 2) may be characterized by the following features, common to all the species of the subfamily:

Malleus of a lamellar type. Head with a large saddle-shaped articular surface for the incus. Collum mallei in its distal part bent outwards to a hook, or almost to a right angle, and prolonged in processus manubrium. Manubrium presents a thin sword- or blade-shaped plate, fastened with its somewhat thickened margin to the inner surface of the tympanum. The exceedingly thin and slender processus gracilis (s. proc. Folli) originates from the median side of the base of manubrium and from the distal part of collum mallei (sometimes only from the latter); it runs parallel to the longitudinal axis of the head and inserts its free end within the Glaser fissure (fissura Glaseri tympano-mastoidea). The space between collum mallei and processus gracilis is occupied by a thin bony plate—the so-called lamina. Apophysis orbicularis is usually absent or reduced. Processus cephalicus and processus muscularis are lacking. Length of malleus does not exceed 3 mm.

Incus differs conspicuously from its usual type. Body of incus—not large in size, its length not exceeding 20 to 50 percent of the total length of the ossicle. Near the base of the body, from its posterior external surface arises a short spiny processus brevis. Processus longus is subject to considerable variation in different genera; it is mostly very long, with a deep elongated groove on its median side.

Stapes—of two types. In some cases it is of the usual stirrup shape (in *Talpa*, *Asioscalops*, *Parascaptor*); in others it differs conspicuously from this plan. The basis stapedis is decidedly convex externally, acquiring the shape of a cup. This peculiar feature does not occur in any of the other Talpidae, nor in any other family of insectivores.

Such are the principle characters of the auditory ossicles common to all the Talpinae. Within the sub-family, however, the ear-bones are subject to some variation, and differ conspicuously in details of structure in the different genera and species.

The following characters of the auditory ossicles must be considered as strictly diagnostic for the genera of the subfamily Talpinae. In both *Talpa* and *Asioscalops* (Plate 1), os mallei is of similar type, and may be characterized by a globular head and very peculiar lamina. Capitulum mallei is somewhat inclined towards the distal end of processus gracilis, and is separated from collum mallei by a distinctly marked, constricted connection. Collum mallei short, slightly curved; it forms with manubrium an angle of about 120°. Processus manubrium—blade-shaped; lamina formed by two plates fused together (an external and an internal one) their combination presenting a slightly curved, hollow, truncate cone, with an open cavity at the base. This peculiarity of structure of the lamina does not occur in any other group of insectivores. Diameter of head constitutes 20-25 percent of the length of incus. The articular surface is in some cases (in *Asioscalops*) displaced on to colum mallei (Plate 1, fig. 4). Incus in representatives of the genera *Talpa* and *Asioscalops* differs from the same in other insectivores by the length of processus longus, which constitutes about $\frac{2}{3}$ of the entire length of the bone. The length of processus longus exceeds that of collum mallei; groove on its median side nearly as long as the process itself, the latter acquiring thus the shape of a canoe. The size of processus brevis varies in different species, but generally it is rather small. Stapes in the mentioned genera is of the usual stirrup-shape.

In *Mogera* and *Eoscalops* (Plate 2), malleus is of similar type, differing only in details. This ossicle differs from malleus in *Talpa* and *Asioscalops* by the structure of the lamina, which does not form a hollow cone, but presents an exceedingly thin externally convex plate. This lamina usually occupies about $\frac{2}{3}$ of the length of the neck; in *Talpa* and *Asioscalops*, all its length.

Capitulum mallei in *Mogera* and *Eoscalops*, contrary to that in *Talpa* and *Asioscalops*, does not present a globular formation, but exhibits only a well developed thickening of the saddle-shaped articular surface. The head is not separated from the neck by any constricted connection. Manubrium is blade-shaped.

Incus in *Mogera* and *Eoscalops* may be distinguished by a greater development of the articular surface for malleus. Processus brevis presents a distinct cone-shaped, sharply pointed process, placed perpendicularly to the longitudinal axis of processus longus, whereas in *Talpa* and *Asioscalops* it is inclined obliquely to the proximal part of processus longus.

Processus longus in *Mogera* and *Eoscalops* is relatively short, not reaching half the length of this process in *Talpa* and *Asioscalops*. Stapes with typical cup-shaped basis stapedis.

The outlines of the auditory ossicles in *Parascaptor* (Plate 3, figs. 1 and 2) present a sharp contrast to those of other Recent moles. The disproportion in the development of different elements of these ossicles constitutes their principal distinguishing feature.

Malleus consists of an enormous hypertrophied globular capitulum mallei, 5–6 times larger in size than the remaining elements of that ossicle. The articular surface is insignificant. Collum mallei—restricted. Manubrium—very slim, saber-shaped, much shorter than processus gracilis. Apophysis orbicularis present, but not adequately developed in different species. In *Parascaptor leucura* Blyth it is rudimentary; in *Parascaptor grandidens* Stroganov, well developed. Lamina extends from capitulum mallei, in the shape of a small triangular plate, merging into processus gracilis.

Incus in *Parascaptor* may also be easily distinguished from that of all other representatives of the Talpinae by a relatively ill developed corpus incudis, smaller articular surface and peculiar shape of processus brevis. This process is exceedingly small, almost reduced, and deviates from incus, forming a right angle with the longitudinal axis of processus longus.

Stapes is stirrup-shaped, but differing slightly from that of *Talpa* and *Asioscalops* in general outline and more ovally-stretched basis stapedis.

SUBFAMILY SCALOPINAE

The auditory ossicles of the North American subfamily Scalopinae (Plate 3, figs. 3 and 4; Plate 4, fig. 1) differ from those of the Talpinae in a number of characters. The ear bones in the Scalopinae are all conformably more massive, and exhibit sharper outlines than the same in Talpinae.

Malleus with a highly developed, long, cylindrical collum mallei, the latter presenting the largest element of the ossicle in question. The proximal end of collum mallei is bent externally in a hook, forming almost a right angle; then, narrowing abruptly, it protracts into a relatively short manubrium. Capitulum mallei presents a massive bony formation with an extensive articular surface, which occupies almost all the space of the cross-section of this formation. From the external side of the head there arises a relatively short and stout processus cephalicus, absent in the Talpinae. Apophysis orbicularis is reduced; processus gracilis reduced also, and may be distinguished only with the help of a lens. Lamina presents a small, flat and exceedingly thin, transparent, triangular plate; processus muscularis absent.

Incus in side view has the shape of a spade. Processus longus is straight and long; processus brevis presents an angular process, rising from the external side of the body of incus. Stapes—stirrup-shaped.

Malleus of the genus *Scalopus* differs from that of the genus *Scapanus* by its larger size and peculiar manubrium. In *Scalopus* the manubrium forms an obtuse angle with the proximal part of the neck, which is bent externally. In *Scapanus* both mentioned elements extend in a straight line. In *Scapanus* processus longus is thinner and shorter, and processus brevis is much longer than in *Scalopus*. Stapes of the same height in both genera, but in *Scalopus* it is about twice as wide as in *Scapanus*.

SUBFAMILY CONDYLURINAE

The auditory ossicles of the subfamily Condylurinae (Plate 4, fig. 2), now represented by the monotypic genus *Condylura*, differ conspicuously in general outlines from those of the Talpinae and Scalopinae and are similar to the ear-bones of Uropsilinae, and in part to those of the shrews (Soricidae).

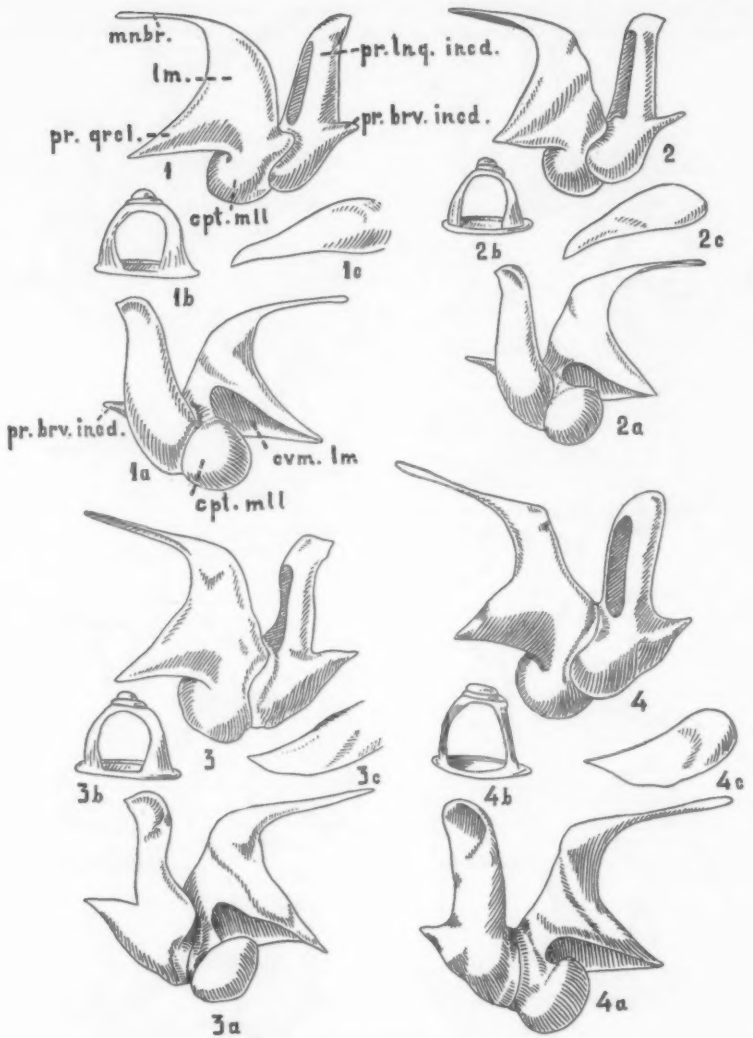

PLATE 1

Auditory ossicles of moles. Figs. 1–1c: Malleus, incus, stapes and manubrium of *Talpa europaea* L.; figs. 2–2C; of *Talpa coeca* Savi; figs. 3–3c: of *Talpa romana* Thos.; figs. 4–4c: of *Talpa* (*Asioscalops*) *altaica* Nikolsky. mnbr.—manubrium; lm.—lamina; pr. gracl.—processus gracilis; cpt. mll.—capitulum mallei; pr. lng. incd.—processus longus incudis; pr. brv. incd.—processus brevis incudis; cvm. lm.—cavum lamina; pr. cphl.—processus cephalicus; apphs. orbc.—apophysis orbicularis.

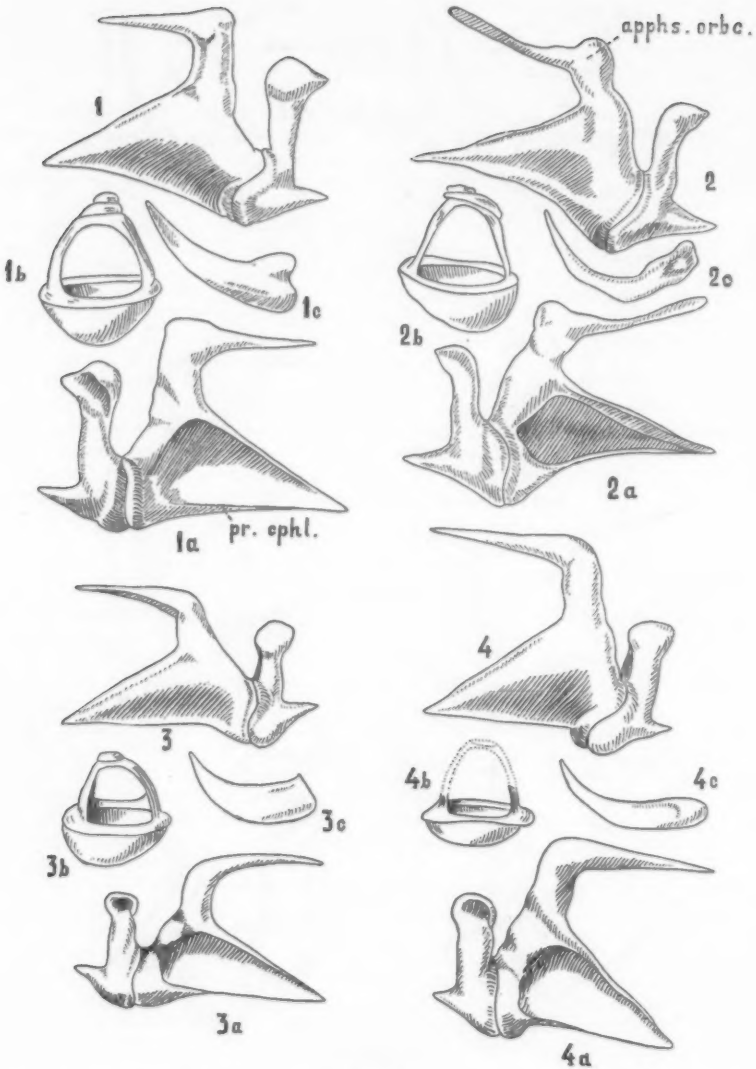

PLATE 2

Auditory ossicles of moles. Figs. 1–1c: of *Mogera robusta* Nehring; figs. 2–2c: of *Mogera wogura* Temminck; figs. 3–3c: of *Eoscalops longirostris* M.-Edwards; figs. 4–4c: of *Eoscalops micrura* Hodgson.

The malleus of *Condylura* may be characterized by the following features: capitulum mallei small, with a saddle-shaped articular surface; collum mallei long, very thin (thread-

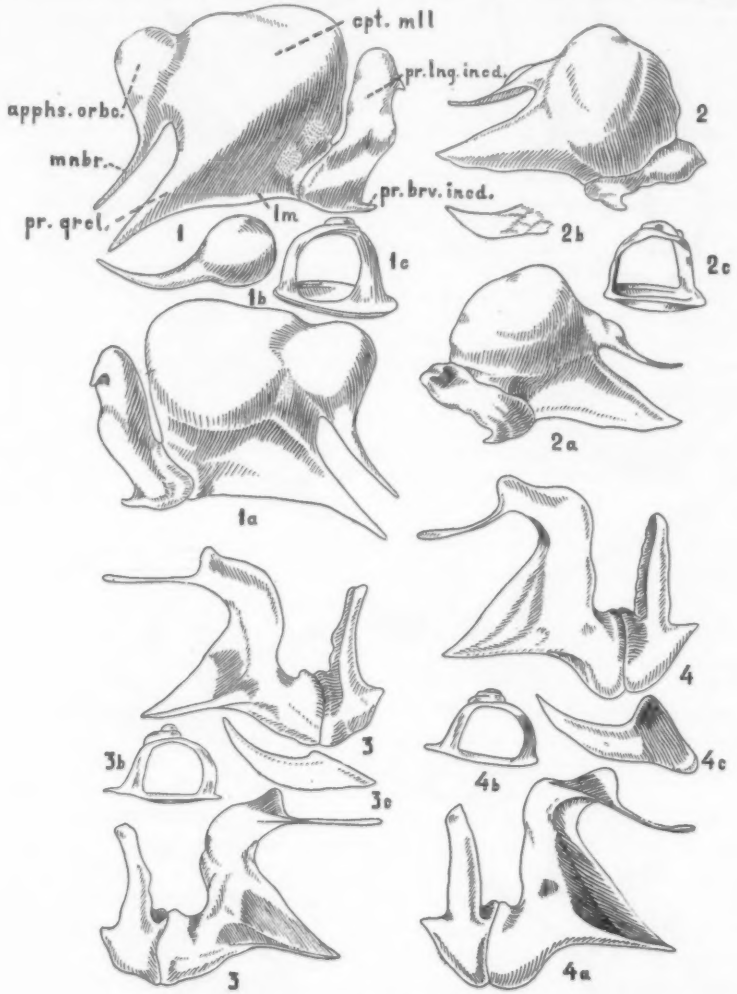

PLATE 3

Auditory ossicles of moles. Figs. 1–1c: of *Parascaptor grandidens* Stroganov; figs. 2–2c: *Parascaptor leucura* Blyth; figs. 3–3c: of *Scalopus* sp.; figs. 4–4c: of *Scalopus* sp.

like), forming a sharp protruding angle half way between the head and the handle of the hammer. In the region of the distal part of collum mallei and of the proximal part of manubrium a flattened bony formation may be distinguished; in side view, it is square-shaped

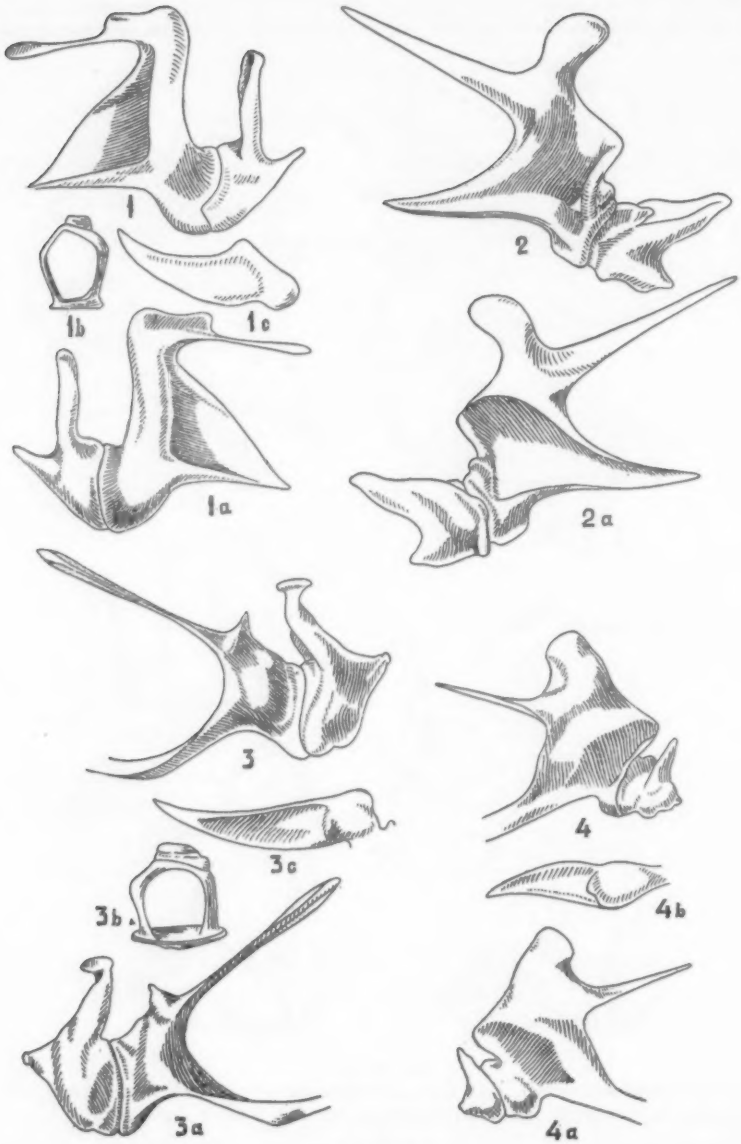

PLATE 4

Auditory ossicles of moles. Figs. 1–1c: of *Scapanus* sp.; figs. 2–2c: of *Condylura cristata* L.; figs. 3–3c: of *Desmana moschata* L.; figs. 4–4b: of *Urotrichus talpoides* Temminck.

and more than twice the size of capitulum mallei; a large finger-shaped apophysis orbicularis extends outward from the bony formation described. Processus gracilis is directed medially, forming an acute angle with processus cephalicus; manubrium is one and a half times longer than processus gracilis; lamina presents a thin triangular plate, bounded by collum mallei, processus gracilis and processus cephalicus.

Incus is peculiar. The body of this ossicle is about twice the size of capitulum mallei; articular surface extensive, occupying all the median side of corpus incudis. Processus brevis stout and blunt, originating from the base of incus; processus longus bent outwardly, forming an obtuse angle with the longitudinal axis of incus. Stapes stirrup-shaped.

SUBFAMILY UROTRICHINAE

The auditory ossicles of Urotrichinae (Plate 4, fig. 3), as far as one can judge from the study of the ear bones of *Urotrichus talpoides*, are somewhat similar in general outlines to those of the Condylurinae, Desmanidae and some of the Muridae (Cockerell et al., 1914).

Malleus resembles that of Condylurinae, but is relatively smaller in size. Collum mallei, as in Condylurinae—very thin, thread-like and bent at a right angle in the middle. The bony formation in the region of the distal part of collum mallei and of the proximal part of manubrium is more developed than in the Condylurinae, presenting in side view a trapezium (not a square). Apophysis orbicularis larger than that of Condylurinae; exhibits but a slight incline towards manubrium. Processus gracilis rather stout; processus cephalicus present; manubrium thin and slender, comparatively long.

Incus elongated-oval in side view, with an extensive articular surface. Body of incus gradually merges into a very short processus longus. Processus brevis thick at base, narrowing abruptly downwards; in side view, presenting an isosceles triangle. Stapes—stirrup-shaped.

CONCLUSIONS

A study of the morphological characters of the auditory ossicles of the Talpidae enable us to draw the following conclusions:

(1) A comparison of the auditory ossicles of the different Talpidae with those of other mammals exhibits a number of primitive features, characteristic of the moles. It may be added that we are unable to discover any decidedly advanced features in the structure of the ear bones of the Talpidae homologous with those of other mammals. All the ossicles of moles have exclusively primitive characters. Even many of the most primitive groups of insectivores differ from Talpidae by some more advanced elements of their auditory ossicles.

The primitive state of development of the ear bones of moles is revealed by the following features: Lamellar type of malleus, with an extensive lamina; presence of an elongated processus gracilis and of a well developed processus cephalicus; lack or restriction of apophysis orbicularis; absence of processus muscularis. On the strength of these features the moles may be regarded, as a group, closely related not only to the most primitive insectivores, but also to the marsupials. It would be a mistake, however, to judge of the grade of specialization of different systematic groups of the Talpidae only on the base of the auditory ossicles. The ear bones may only support suggestions based on many other characters.

(2) According to the above given review, the auditory ossicles of the Talpidae are not only of diagnostic but also of phylogenetic significance. They characterize different subfamilies and genera of the Talpidae and throw light on the phylogenetic relations between separate forms of moles.

A curious almost total resemblance in the characters of the ear bones has been discovered in *Mogera* and *Eoscalops*. These moles differ from each other by their dental formula, by the structure of the pelvis bones, and by the position of the nostrils. *Eoscalops* has the same dental formula as *Talpa*, but the structure of the teeth is more similar to that in *Mogera*. *Eoscalops* differs essentially from *Mogera* in the structure of the pelvis and somewhat resembles *Talpa*. The position of the nostrils, which are directed somewhat externally, and not forwards, is a peculiar feature of *Eoscalops*. The auditory ossicles of *Eoscalops* and *Mogera* differ conspicuously in shape from those of *Talpa*. I suggest that the mentioned similarity of the auditory ossicles of *Eoscalops* and *Mogera* may be explained by close relationship, not by convergent development of distantly related groups. The habitat of the chinese genus *Parascaptor* is similar to that of *Mogera* and *Eoscalops*, but the former genus differs conspicuously from the other two by its auditory ossicles and dental system.

(3) We have reasons to presume, that the transition to underground life in the different groups of moles did not take place simultaneously, but at different moments of their evolution. The lack of apophysis orbicularis in most specialized Talpinae and the reduced condition of that element of the malleus in Scalopinae suggest an earlier transition to underground life of the latter group of moles. The stage of development of apophysis orbicularis in Condylurinae and Uropsilinae approaches the condition found in most mammals that live above the ground. The specialization of these forms of moles probably began at a later time than that of the Scalopinae and particularly of the Talpinae.

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THE HINDFOOT MUSCULATURE OF SOME BASIC UNGULATES

By Berry Campbell

In an earlier paper (1936), I have discussed the forelimb myology of the hippopotamus, pig, and tapir. The striking tendencies associated with the limited and simplified mode of progression of the hoofed animals was shown to be clearly begun already in those rather basic forms. In this account will be added a description and discussion of the musculature of the hindfoot. As will be shown, the hindfoot is more highly specialized than the fore in these animals, but as this seems to be true of the mammalian group as a whole, few of the changes are characteristic of the ungulates. The reduction and loss of digits, especially in the peccary has produced some interesting rearrangements of parts which are of more than passing interest.

The species studied are *Choeropis liberiensis*, *Tapirus americanus*, *Tayassu crusnigrum*, and *Sus scrofa*.

MUSCLES OF FOOT

M. extensor digitorum brevis pedis

Hippopotamus: This flat, wedge-shaped muscle takes origin from the calcaneus, talus, and cuboid. It is partly separable into a superficial medial and a deep lateral belly, the latter being about five times the size of the former. Half of the small belly inserts with the long extensor tendon of the second toe and half into the dorsal aponeurosis of the third. The large belly inserts into the dorsal aponeurosis of all four toes.

Pig: Origin and division resemble that of the hippopotamus. In one animal the small medial tendon formed the entire long extensor tendon to the second toe, in the other it came entirely from the extensor digitorum longus, and the small belly of the short extensor inserted on the capsule of the third metatarso-phalangeal joint.

Peccary: There is no division of the muscle evident, but three main insertions may be made out—one to the long extensor tendon of the second toe, a second to the proximal phalanx of the third toe, and a third to the combined long tendon of the third and fourth toes.

Tapir: Origin is from the calcaneus and the distal end of the fibula. It inserts into the dorsal aponeuroses of the toes, principally that of the third.

Innervation: Deep peroneal nerve.

M. flexor digitorum brevis pedis

In none of the animals was this muscle present. It is possible, however, that the fleshy fibers found in the plantar expansion of the plantaris are vestiges of the superficial short flexor elements. That the insertion of the plantaris in all cases is by means of perforated tendons is good evidence that a fusion with the flexor digitorum brevis pedis has occurred.

Mm. lumbricales pedis

Hippopotamus: The single lumbrical arises from the crotch of the deep tendons to the third and fourth toes and inserts upon the medial side of the basal phalanx of the fourth.

Pig and Peccary: Absent.

Tapir: There are three lumbricals, one to each digit. The lateral two have bicipital origins from the crotches between the long flexor tendons. The medial muscle arises by one head from the medial side of the tendon to the second toe. Insertion in each instance is on the medial side of the middle phalanx of the respective digit.

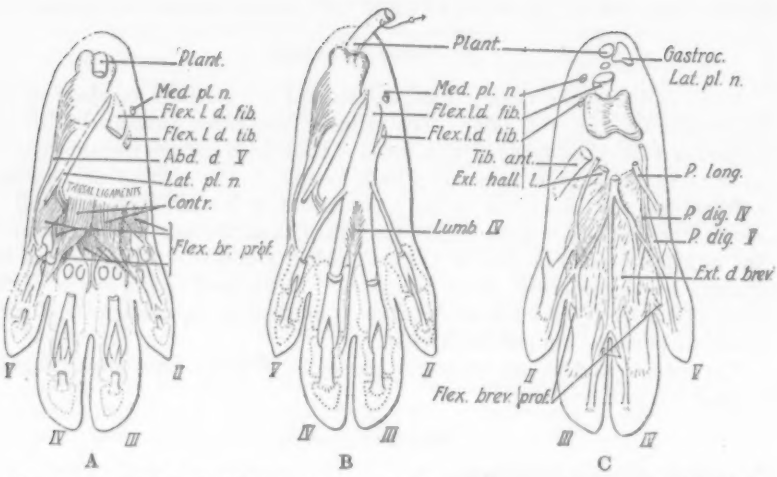

FIG. 1. Dissected foot of hippopotamus. A., Deep volar muscles; B., superficial volar muscles; C., dorsal muscles.

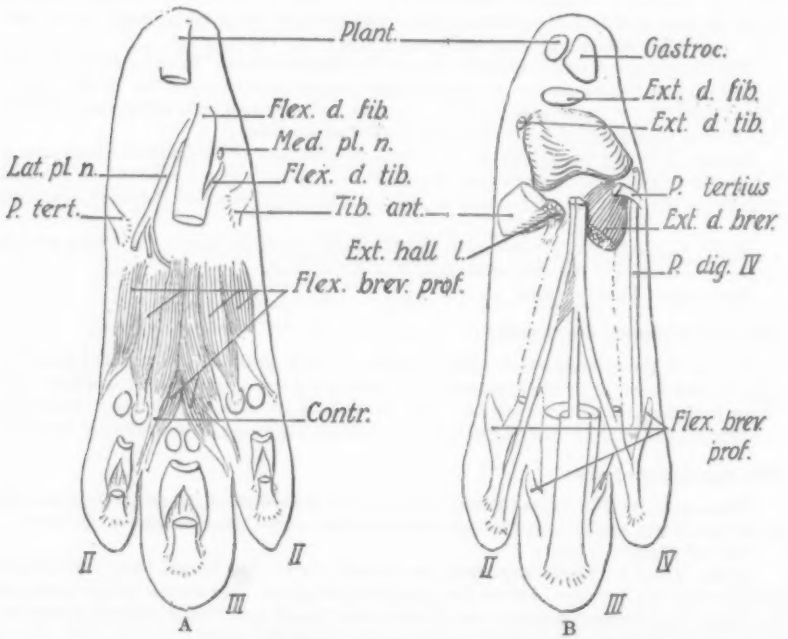

FIG. 2. Dissected foot of tapir. A., Deep volar muscles; B., dorsal muscles

Innervation: The muscles to the fourth toe in both the hippopotamus and the tapir receive small twigs from the deep branch of the lateral plantar nerve. The nerve supply of the rest was not determined.

M. abductor digiti quinti pedis

Hippopotamus: This is fleshy and well developed. Origin is from the lateral surface of the calcaneus. The insertion is by means of a thin tendon to the outer sesamoid and into the lateral aponeurosis of the fifth digit.

Pig: The muscle is indicated by a ligamentous structure with corresponding attachments.

Peccary and tapir: Absent.

Innervation: Branch of the lateral plantar nerve.

Mm. contrahentes digitorum pedis

Hippopotamus: In this animal, and in the other artiodactyls dissected, there is a contrahens to the second and one to the fifth toe. The origin is from the tarsal ligaments and sesamoid. Insertion is upon the axial side of the proximal phalanx of the toes.

Pig: The muscles resemble those in the hippopotamus, except that they are relatively reduced.

Peccary: It is particularly interesting to find that in this animal, in which the fifth toe is lost, the contrahens for this digit remains. It is only half the size of the reduced contrahens digiti secundi. It takes origin from the proximal end of the axial ligament (which probably represents the fibular head of the flexor brevis profundus to the third toe and the tibial head to the fourth). The minute tendon of this muscle fuses with that of the fibular head of the flexor brevis profundus to the fourth toe. The contrahens to the second toe has a similar origin and inserts upon the axial side of the proximal phalanx of the digit.

Tapir: Contrahentes are present for the second and fourth toes. Origin is from the tarsal ligaments, and insertion is upon the axial side of the proximal phalanges of the two toes.

Innervation: In all cases the deep branch of the lateral plantar nerve supplied these muscles. In both the hippopotamus and tapir the nerve pierced the muscles near their origins.

Mm. flexores breves profundi pedis (interossei)

Hippopotamus and pig: These muscles resemble closely the corresponding structures in the manus. There are two muscles, with common origin, for each digit. The axial muscles for the second and fifth toe are reduced—a fact which can be correlated with the presence of the contrahentes—and insert on the sesamoids. The outer or paraxial slips for these toes insert into the extensor aponeuroses as well as upon the sesamoids. Both muscles of the third and fourth toes are heavily developed and insert into the extensor aponeuroses.

Peccary: The axial muscles of the third and fourth toes have lost their fleshy nature and have become ligamentous. They attach distally to the sesamoids at the metatarso-phalangeal joints. The remainder of the muscles resemble those of the hippopotamus.

Tapir: There are two muscles for each of the three toes. The paraxial elements of the second and fourth toes insert on the corresponding sesamoids and into the extensor aponeurosis. The axial muscles of those toes insert only on the sesamoids and their ligaments. The two muscles for the axial or third toe insert into the extensor aponeurosis. The homologies of these muscles with those of the primates and other mammals have been previously discussed (Campbell, 1936, 1939).

Innervation: Deep branch of lateral plantar nerve.

DISCUSSION

The evolutionary tendencies seen in the hind limb, while not so limited to the ungulate group as those previously described for the shoulder girdle, are all to be

interpreted with reference to the locomotor behavior patterns of the group. In these basic forms studied, the tendencies that are carried to extreme in the ruminants and the horses are seen in the beginning stages. The reduction of the number of toes and the lengthening of the metapodial segments are the notable processes. Limitation of the use of the hind foot to support of the body has operated to simplify the muscular system. The loss of the fleshy nature of the flexor digitorum pedis illustrates the point. It is remarkable, however, that the flexores profundi remain in such a primitive condition. Only in the peccary was the fleshy nature of certain of the members lost. While reduction in the number of digits usually means the dropping of all parts associated with the missing members, the surprising conservatism of the muscular system is seen in the disposition of the contrahens of the 5th toe. This has become a vestigial structure and has shifted its insertion to the 4th toe.

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SOME ANATOMICAL CHARACTERISTICS OF THE HUTIA CONGA

BY JUAN J. ANGULO

In the course of a study on sex biology of the Cuban hutia, *Capromys pilorides* (Say), some anatomical details were found which are described here. It is interesting to note first, that this animal presents, among others, a very curious disposition of the rectus abdominis muscle consisting in the decussation and interlacing of its bundles at their pubic insertion (Alvarez and Angulo, 1944). It shows also a striking subdivision of the liver lobes which look like a human brain, but with deeper fissurae (la Sagra, 1845). Two sub-species: *C. p. pilorides and C. p. relictus* exist, both living in Cuba and the adjacent keys; other genera of the sub-family Capromyinae are found in Jamaica, Bahamas, Santo Domingo and Venezuela (Tate, 1935). Adult males of the hutia conga weigh about 3 kg; females about 2.5 kg, although very large individuals weighing as much as 5 kg are frequently found. This autochthonous rodent has a general morphological resemblance to a gray rat.

GENITAL TRACT OF THE FEMALE

The most striking features of the reproductive apparatus of the female hutia are pointed out here; the male one has been described elsewhere (Alvarez and Angulo, *op. cit.*). The external genitalia have the basic disposition of the rat, but the clitoris is a true cone, in the vertex of which the urethral meatus is located. The clitoris is 25 mm long and practically occludes the vaginal opening.

PLATE 1

UPPER: The lateral position of the mammae in hutia. The black dots indicate the position of the nipples.

LOWER: X-ray of the hutia's fore foot, showing vestigial nature of the thumb.

The development of this organ is such that it frequently is mistaken for the penis by the inexperienced.

The vagina is closed in immature hutias, opening at puberty as happens in the mouse, the rat and other species. The vagina of the adult hutia is 12 cm long, extending through all the pelvis and advancing 1 cm or more into the abdominal cavity. There is only one external opening (os uterus) for the two horns of the uterus, this organ being of the bipartitus type—not frequent in rodents. Continuous to the vaginal opening of the uterus, there is an atrium or vestibule about 6 mm long at the anterior end of which each uterine horn opens, separated from each other by about 3 mm.

A notable feature presented by the female is the position of the ovaries, which are situated adjoining the external edge of the kidneys, at their same level, so that no point of the ovary is posterior to the posterior pole of the kidney. The ovary is not globular, having two faces—one convex, more or less laterally flattened, and the other flat. A deep longitudinal sulcus is found on the latter surface allowing for the insertion of the mesovarium with the ovarian vessels.

THE MAMMAE

An occasional observation of a newborn while feeding showed that its lips were on the flanks or sides of the mother. Upon close examination it was found that the nipples in this rodent are situated not on the ventral part of the body as happens in most of the mammals, but rather on the sides (Plate 1, upper), approximately 4 cm dorsad to a line passing through the external limits of the axilla and groin. Consequently, the female nurses the young in no special position; perhaps this location of the mammae facilitates nursing while the animals are in the trees, in which they live. In this respect we have observed that at birth hutias have open eyes, full hair and full movements.

There are four mammae symmetrically situated by pairs on both sides of the body. The anterior pair is thoracic and the posterior abdominal, about 9 cm apart. Each thoracic nipple is located practically at the mid-point between the dorsal and ventral midlines. The abdominal teats are a little nearer to the ventral line because of the morphology of the body at that level.

In Turner's "Comparative Anatomy of the Mammary Glands" (1939) we have seen no description of such lateral position in any mammal.

CECUM

The hutia has a well developed cecum, correlated with its food habits. It eats mostly foods rich in cellulose, such as the bark of trees, roots, fruits, etc.

The normal cecum is about 45 cm long by 6 cm wide. The cecum is approximately one-tenth the length of the remaining intestine. There is no cecal inner spiral valve or cecal appendix as occurs in rabbits. In 41 supined cadavers of hutias, we have found a notable variability in the shapes and positions of the cecum in the abdominal cavity. In the rabbit, the spiral form of the cecum has been described (Bensley, 1938); in the hutia, we have noticed triangular and more or less convoluted shapes; the cecum may be situated laterally, either to the left

or to the right, or centrally occupying the ventral and posterior two-thirds of the abdominal cavity, in such a way that the ileocecal aperture may be found at

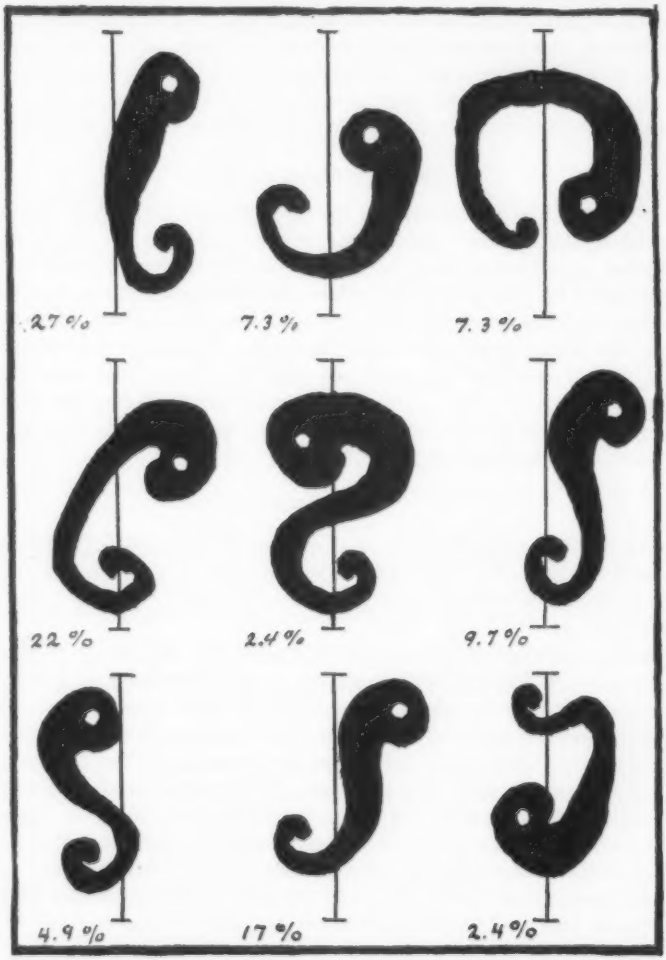

FIG. 1. Shapes and positions of the hutia cecum in the abdominal cavity as found in 41 specimens (schematic). The white circles represent the ileo-cecal aperture. Vertical line represents the mid-body line.

different points, although the middle of the left flank is the most frequent position. In Figure 1 are shown the shapes and positions assumed by the cecum with their percentage of frequency in the 41 specimens examined.

The cause of such variability in shape, similar to what happens in the small intestine, was investigated and it was found that, on account the above-mentioned food habits of the hutia the cecum is always filled with a comparatively enormous weight. This is distributed along a wide, long and flexible tube which is attached to the posterior abdominal wall by means of the lax peritoneum, which in turn constitutes a meso converging from all the length of the cecum to a point on the dorsal body wall well anteriorly in the abdominal cavity. No ligaments are present to fix the cecum to the walls of the abdomen, as occurs in man.

THE ILEO-CECAL VALVE

The structure which represents in the hutia the ileo-cecal valve is strikingly different from that of man. Instead of two lips which shut by contact, as occurs in the latter, a septum is found, being the base of a truncated cone whose walls are constituted by the sacculus rotundus. In the septum, there is an excentrically situated circular opening with a rounded free edge. These findings in the cadaver were later checked in a living specimen. No sign of a sphincter at the opening was observed in any case. In one instance, several fatty drop-like inclusions were seen forming a layer in the tissue around the free edge of the ileo-cecal septum. In an adult male, 3 kg in weight, the septum and its opening were 12 mm and 4 mm in diameter, respectively.

HAIR COLOR

Chapman (1901) observed in a small number of specimens of hutia that the palest were females. He suggested the possibility of sexual dichromotism. On the other hand, it is believed among farmers that the presence of white hair is related to old age.

The author has studied in a 16 months' period, 227 individuals of all ages at the Laboratory of Experimental Pathology of the University of Havana. Of these, about 50 were females. In addition, he has momentarily examined between 300 and 400 other wild-caught hutias of both sexes at the Havana market. Contrary to Chapman's findings, several males were practically white and no sexual difference in color was observed. The presence of more or less abundant white hair was found in both sexes, both young and old. In this respect, we have seen the change of color from a quite uniform admixture of pale brown and black to one of white, gray and black in the course of three or four months in two young ones brought to the laboratory when three months old and kept under circumstances that would not foster a nutritional cause of the change.

THUMB SKELETON

The disposition of the hutia's feet offers no special characteristics except of the fore limb. Some habits of this rodent will be pointed out before describing the roentgenological findings. When feeding or attacked, the hutia adopts a bipedal position, using the tail and hind feet in supporting the body; the fore feet are used simultaneously in feeding and in defense when attacked.

Despite the well developed faculty of grasping, the hand has externally only four fingers, the thumb being represented by a mere tip, with a poorly developed nail rather than a claw, inserted in the palm. It has no individual movements and therefore no function in prehension.

To investigate the degree of skeletal development of the thumb, we took an infantile, one young, and one adult specimens for radiological examination, for which work we are indebted to Dr. G. Elizondo.

The X-ray films showed the hutia's thumb to be structurally complete (Pl. 1, lower). Neither the phalanges nor the corresponding metacarpal are lacking, although practically the whole digit is enclosed inside the palm.

A comparison of the development of the elements of the thumb and the second finger shows: (1) the phalanges are quite normally developed for a thumb, (2) the first metacarpal is less than one-third the size of the second one, while in the human, for instance, it is about two-thirds, (3) the total length of the phalanges and the first metacarpal is slightly less than that of the second metacarpal, (4) the carpo-metacarpian interline is regularly convex and no slit is seen in the carpus that may justify the shortness of the first metacarpal. Therefore, the immediate cause of the apparent absence of the thumb is the poorly developed metacarpal. This is true at any age as shown by the X-ray examination. The growth cartilages showed no important difference from those of the remaining fingers and sesamoid bones were present in every metacarpophalangeal articulation.

X-RAY IMAGE OF SELLA TURCICA

Radiological examination of infantile, young, and fully adult hutias showed that the sella turcica is flattened and elongated. No evidence was found of the clinoid processes, which, if present, are seemingly represented by cartilages.

SPLEEN

The weights of 8 adult hutias spleens ranged from 3.2 gm to 10 gm with an average of 6 gm. The lengths were from 56 mm to 92 mm and the maximum widths ranged from 15 mm to 25 mm; the average maximum width and length were 20 mm and 71 mm, respectively. Spleens are not rarely observed with their left ends quite on the anterior face of the stomach, but with no signs of hypertrophy.

HEART AND GALL-BLADDER

Another feature which may be noted in the hutia even without actual measurements is the heart size. It is about one-third larger than one of a rabbit of equal weight and sex. These findings have been checked in about 10 specimens. The size of the gall-bladder may be judged by the following aproximate dimensions: a capacity of 10 ml, a length of 45 mm and a width of 25 mm. Its excretory duct is 47 mm long.

SUMMARY

(1) Some details of the anatomy of the hutia conga (*Capromys pilorides*) are described.

(2) In the female genital tract are pointed out: the long conical clitoris, the length and partially abdominal position of the vagina, the comparatively anterior position of the ovaries, just adjacent to the kidneys and not posterior to them; the two faces of the ovary—one convex and one flat, the latter with a deep longitudinal sulcus to allow the insertion of the mesovarium.

(3) The lateral position of the mammae which are dorsad to the axilla and groin is noted. These glands are symmetrically situated in two pairs, one thoracic and one abdominal.

(4) The comparative development of heart, gall-bladder and spleen; the flattening and elongation of the sella turcica and the different shapes and positions of the cecum in the abdominal cavity are described.

(5) The ileo-cecal valve is represented in the hutia by a septum with an excentric circular aperture.

(6) X-rays of the seemingly four-fingered fore foot demonstrated the presence of thumb phalanges and the first metacarpal inside the palm. The metacarpal is poorly developed so that it and the phalanges have a total length slightly less than that of the second metacarpal.

(7) Observation of more than 500 hutias showed no relation of hair color to sex or age, as suggested by some authors.

ACKNOWLEDGEMENTS

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A NEW BADGER FROM WISCONSIN

By Viola S. Schantz

While examining the badgers of North America I came across a new dark eastern form hitherto unrecognized from Wisconsin. I shall name it for the collector, Dr. Hartley Harrad Thompson Jackson, and its description is as follows:

Taxidea taxus jacksoni, subsp. nov.

Type.—Adult male, skin and skull, no. 117315, U. S. National Museum (Biological Surveys Collection); collected 4 miles east of Milton, Rock County, Wisconsin, by Hartley H. T. Jackson, June 13, 1902; original number 3739-X.

Distribution.—Southern Wisconsin and southern Minnesota; limits of range undetermined. Illinoian province (Dice). Transition Zone.

General Characters.—Similar to *Taxidea taxus neglecta* but dark markings more accentuated on face, head, and back of ears. Very much darker than *Taxidea taxus taxus* with under fur more reddish. Auditory bullae less inflated and mastoid less rounded than in *taxus* or *neglecta*.

Color.—Type: Face, including the eyes and forehead (except median line), and patches on sides of face in front of the ears black, as customary in the species; white irregular markings under and behind the eyes merge with buffy-white underparts; general dorsal area and sides of body with a reddish-buff underfur, with hairs widely banded with black and tipped with gray, giving a black and reddish-buff, slightly grizzled effect; median white line extends from middle of face to near shoulders; ears blackish, edged with white; vibrissae and spot above median line blackish; chin grayish brown; throat buffy-white; general abdominal area reddish-buff, becoming buffy-white along a narrow median line; fore and hind legs black; tail similar to back but less grizzled and more ochraceous-tawny, terminating with a brownish-black tip.

Skull.—Slightly smaller than *taxus;* auditory bullae less inflated and mastoids less rounded than in *taxus* or *neglecta*.

Measurements.—Type: Total length 765 mm; tail vertebrae 132; hind foot 103. Skull: condylobasal length, 123.1; zygomatic breadth, 87.4; breadth of braincase (across mastoid processes), 77; height of braincase (over auditory bullae), 49.2 interorbital breadth, 29; postorbital constriction, 28.1; palatal constriction, 14.2; maxillary toothrow (alveoli), 41.5; crown length (outerside) of 3rd upper premolar, 11.3; crown width of 3rd upper premolar, 12.5

Remarks.—*Taxidea taxus jacksoni*, while intergrading with *T. t. taxus*, appears to be more closely related to *T. t. neglectus*, excepting for the less rounded mastoids and less inflated auditory bullae. The skins closely resemble those of *neglectus* but average darker.

Specimens.—Total number 10 as follows: **Wisconsin:** Delavan, Walworth County, 1; Emerald Grove, Rock County 1; Milton, 4 miles east, Rock County, (type locality) 1; **Minnesota:** Elk River, Sherburne County, 6; Madison, Lac qui Parle County, 1.

Fish and Wildlife Service, Washington, D. C.

GENERAL NOTES

THE LOCATION OF BRIGG'S MEADOWS, BEAVER MOUNTAINS, UTAH

The type locality of *Eutamias adsitus*, *Marmota engelhardti*, and *Ochotona cinnamomea* was given by J. A. Allen (Mammals from Beaver County, Utah, collected by the Museum Expedition of 1904. Brooklyn Inst. Mus. Science Bull. vol. 1, pp. 117–122, 1905) as Brigg's Meadows in the Beaver Range Mountains. Repeatedly A. H. Howell (N. Am. Fauna, no. 37, p. 45, 1915; N. Am. Fauna, no. 47, p. 46, 1924; N. Am. Fauna, no. 52, p. 93, 1929) has listed "Brigg's" (Britt's) Meadows as the type locality for these animals. During a visit to these mountains in July 1939, the writer attempted to locate Britt's Meadows, but no one of the many older natives of the town of Beaver who were camped near Puffer Lake had ever heard the name before. However, most of them, including U. S. Forest Ranger Christensen and his assistants, knew of Brigg's Meadows which is located about 5 miles by winding highway downhill and west of Puffer Lake. The Delano Ranger Station (shown on older maps as the Tushar Ranger Station) of the Fishlake National Forest is located on the sloping hillside of Brigg's Meadows in Beaver County. Marmots, pikas, and chipmunks were all abundant at this locality.

Many maps erroneously label the Mineral Mountains northwest of the town of Beaver as the Beaver Mountains. The much higher Beaver Mountains, more properly known as the Tushar Mountains, are immediately east of the town of Beaver on the Beaver-Piute County line.—Ross HARDY, *Dixie Junior College, Saint George, Utah.*

SPOTTED SKUNK AND FERAL NUTRIA IN MONTANA

In 1931 (Jour. Mamm. vol. 12, p. 314) the writer recorded a specimen of spotted skunk, *Spilogale gracilis saxatilis* Merriam, from Ravalli County, Montana. Since that time, several trappers have told me of taking a few in the southern part of Ravalli County. A second specimen, a freshly trapped mature male, taken by Bertie Lord at Medicine Springs, Ravelli County, was brought to me on January 27, 1945. The tail was damaged but the body minus tail measured 9¾ inches; the hind foot, 2 inches. Orr (1943, Proc. Calif. Acad. Sci., vol. 23, p. 523) records a single specimen of spotted skunk from the adjacent county, i.e., Idaho County, in Idaho.

Two dried skins of nutria, *Myocastor coypus* (Molina), were secured in February 1945 from a trapper, Frank Engler, who had taken them near Corvallis, Ravalli County, Montana, during November 1946. A third specimen freshly trapped was brought to me on March 14, 1945, from the same area. This animal, a female, weighed 12½ pounds and measured as follows: total length 37½ inches, tail 16 inches, hind foot 5½ inches. The presence of these animals in a feral state in the Bitterroot Valley is accounted for by escapes from a fur farm about 5 miles farther upstream on one of the branches of Gird Creek. On May 20, 1944, a break in a large irrigation ditch flooded this fur farm, owned by Mr. Erdman, and permitted the escape of some breeding stock of nutria that had been imported from South America. In March when the female was trapped and others were reported still at large in the area, all streams were clear of ice and green vegetation had started to grow. The animal was in good physical condition but not fat. The fact that at least one nutria, and probably others, survived a Montana winter in nature with a minimum temperature of −23° F. is a tribute to their adaptability and hardiness. The Museum of Vertebrate Zoology at Berkeley, California, and the Museum of Zoology at Lawrence, Kansas, have each received one of the nutria skins.—WILLIAM L. JELLISON, *Hamilton, Montana.*

THE BISON IN FLORIDA

A recent map in *The Wolves of North America* (The American Wildlife Institute, Washington, 1944, p. 223) shows continued reluctance to extend the former range of the bison (*Bison bison americanus*) to Florida. J. A. Allen (History of the American Bison. Ninth Annual Report U. S. Geological Survey, Washington, 1877, p. 693), after reviewing much of

the early literature, concludes that the statements of its former occurrence are unsatisfactory. He overlooked the remark of William Stork (A Description of East-Florida, with a Journal kept by John Bartram. 3rd ed. London, 1769, p. 19) that: "The buffalo is found in the savannahs, or natural meadows, in the interior parts of East Florida: the peculiarity of the American buffalo is, that instead of hair, it is covered with a fine frizzled wool." *Florida* was in many cases an indefinite geographical area, but Stork defines the northern boundary of East Florida as the St. Mary's River, latitude 30° 47′.

During the expedition of Marcos Delago in 1686, as noted by Mark F. Boyd (Science, vol. 84, 1936, p. 203), the bison was found in Jackson County, Florida, and Houston County, Alabama. J. R. Swanton (Jour. Mamm., vol. 22, 1941, p. 322) quotes from Spanish sources showing that the bison was found in northwestern Florida in 1693. A recently available account is that of William Bartram (Travels in Georgia and Florida, in 1773-74. Trans. Amer. Philosophical Soc., vol. 33, pt. 2, 1943, p. 164) who says: "Buffiloe, a very large creature. This creature is becoming very scarce in Et. Florida yet there remains a few in the Point [probably the peninsula of Florida]. The Indians bring their skins with those of Deer to Stores, the hide is covered with a short, soft curley wool or Furr, of a soft texture." —A. W. Schorger, *Madison, Wisconsin.*

MYOTIS SUBULATUS LEIBII IN ONTARIO

Myotis subulatus leibii (Audubon and Bachman), called the least bat because the smallest in northeastern North America, is also considered the least common species. Only eight specimens were known to Miller and Allen (1928) when writing their monograph of the genus. Since that date more have been discovered, most of them by Mohr. In a report of 10 year's study of bats Mohr (1942) records 272 specimens, 198 of which were banded. The largest number from one locality was 81, at Stover Cave, in central Pennsylvania.

In view of the apparent rarity of the species, the following records of *Myotis subulatus leibii* hibernating in a cave at Fourth Chute, Renfrew County, Ontario, are of interest. On April 5, 1942, 30 specimens were found; on January 6, 1943, 76; on February 26, 1944, 142; and on February 25, 1945, 85. Altogether a total of 301 was counted, of which 194 were banded. The sexes were almost evenly divided, there being 153 males and 148 females.

The Fourth Chute specimens are not the only Canadian records of the least bat, which was first collected by Davis (1931) at Mount Brydges, Middlesex County, Ontario, and later by me (1941) in Tyendinaga Township, Hastings County, Ontario, and at St. Pierre de Wakefield, Gatineau County, Quebec.

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Harold B. Hitchcock, *Department of Biology, Middlebury College, Middlebury, Vermont.*

BIG-EARED BAT IN ILLINOIS

Guided by the local game agent, Bud Hartline, and U. S. Game Management Agent, Paul Smith, I made a search of the abandoned silica and ganister mines in the vicinity of Elco in northeastern Alexander County, Illinois, for possible hibernating bats. We visited four of these artificial caves October 5, 1942, and found only two bats. In one cave a single

male *Pipistrellus s. subflavus* Cuvier was taken. In another cave hung a single very large bat. The first glare of the electric torch revealed the immense ears of what surely was *Corynorhinus r. rafinesquii*. The bat was certainly not in a state of hibernation for it took wing at our first approach and eluded us all before flying out the cave entrance. Although several return trips were made, the bat was not seen again.

Necker and Hatfield (Mammals of Illinois, Chic. Acad. Sc. Bull. Vol. 6, No. 3, 1941) give Mt. Carmel, Wabash Co., as the location of the only previous record for the state.—Wm. H. Elder, *Univ. of Chicago, Chicago, Illinois.*

KOGIA BREVICEPS AND MESOPLODON MIRUS IN THE NEIGHBORHOOD OF THE OREGON INLET, NORTH CAROLINA

Following one of those lapses that occasionally occur in the best conducted museums, I now beg to report the two following unpublished records of nearly two years ago:

In July, 1943, Mr. Samuel Walker, Superintendent of the National Pea Island Reserve, sent in to the N. C. State Museum a small collection of skeletal material picked up along the beach within the previous few months that included the following: Main parts of skull, without mandibles, of True's Beacked whale, *Mesoplodon mirus*, together with the basal parts of the skull of *Kogia breviceps*, the latter without rostrum.

Neither of these is a new record for the State, but both, seemingly, are quite rare.—H. H. Brimley, *N. C. State Museum, Raleigh, North Carolina.*

IDENTITY OF THE CENTRAL TEXAS BEAR

Although I have no recent record of the black bear in central Texas, a few occurred in Kerr County as late as 1902 (Bailey, North Amer. Fauna, no. 25, p. 186, 1905) and one was killed in 1893, 8 miles north of New Braunsfels, Comal County, by John Nowotny and Albert Nowotny, Sr. On the basis of geographic probability, Bailey (*op. cit.*) referred these central Texas bears to the eastern race, *Ursus americanus americanus* Pallas.

In 1938, Pierce Uzzell, a former student of this department, presented us with a large, incomplete bear skull that he found in a cave on the Bacon Ranch in the southern part of Edwards County. This skull, undoubtedly a male, proves to be most closely allied to the bears of Trans-Pecos Texas, New Mexico, and northern Coahuila, currently known as *Ursus americanus amblyceps* Baird. The ratio of zygomatic breadth to total length of skull is 0.644; alveolar length of upper tooth row (Pm^3 to M^1), 50.6 mm; frontal shield flattened. These characters compare favorably with Baird's description of *ambliceps* (U. S. and Mex. Bound. Surv., pt. 2, p. 29, 1859) and also with specimens from northern Coahuila, Mexico. If the eastern black bear ever occurred in Texas, its range was limited to the northern part of the state.—William B. Davis, *Department of Fish and Game, Agricultural and Mechanical College of Texas, College Station, Texas.*

FIVE FETUSES REPORTED FOR PECARI ANGULATUS FROM ARIZONA

Recently (February 1945) while in conversation with William A. Phillips, M.D., of Yuma, Arizona, we learned that he had dissected a female javelina (*Pecari angulatus*) finding three fetuses in the right and two in the left horn of the uterus. Unfortunately these unborn young, which averaged approximately four centimeters long, were not preserved as specimens.

This sow was shot by Dr. Phillips on February 22, 1942, the opening date of the hunting season, in the foothills of the Catalina Mountains, Pima County, Arizona. H. E. Anthony (*Field Book of N. Amer. Mammals*, 1928, p. 513) states that the peccary has but two young at birth. Theodore Knipe (*Pittman-Robertson Quarterly*, vol. 2, no. 3, p. 135) reported an Arizona animal containing six embryos. Inasmuch as animals of either sex can be legally killed during the Arizona open season, it would be a comparatively easy matter to ascertain if this condition is unusual or if javelinas rather regularly carry more than two young. —Arthur F. Halloran, *Fish and Wildlife Service, Yuma, Arizona.*

ACTIVITY OF THE SIERRA PINE MARTEN

Seton, in his "Lives of Game Animals", says the marten (*Martes*) is seldom seen by man, and bases most of his discussion on the observation of caged or trapped animals. In view of this the following experience is recorded.

In company with Earle Thorburn, a fellow hiker, I was camped at the outlet of Washburn Lake, elevation 7,640 feet, Merced Canyon, Yosemite National Park, California, on August 25, 1944. The lake was partly surrounded by lodgepole pine (*Pinus contorta*), but above this on both sides of the canyon were rock slides.

I was awakened in the gray of early dawn by the shrill chatter of a chickaree (*Sciurus douglasii*). It was clinging to the bark of a lodgepole pine just above my head. The squirrel suddenly became silent and the next thing I heard in the now silent forest was the soft patter of feet. I do not know whether the squirrel chattered because it had suddenly seen me or the marten, but after becoming silent it quickly disappeared. Looking the other way I saw a pine marten (*Martes caurina*) coming down through our camp site. It passed within a few feet of me and paused to take a few bites out of the frying pan, which contained bacon grease that had been used to fry fish. Upon later examination I learned that it had taken several bites, but had not cleaned the pan. It then looked over the spot on a flat rock where I had incautiously left two large chunks of fat bacon. Later I found that they were gone. There was no evidence that the marten had taken them on an earlier trip, but they were clumsy pieces for one of the smaller creatures to carry away. The marten then carefully explored the camp and, from the top of a rock, looked me over. By this time I had raised on one elbow, but even this did not seem to bother it. It then quickly nosed each food item that had been left out on the rock but did not bother anything. I expected to see the eggs examined more closely, or one picked up, but such did not happen. The marten then disappeared near a huge rock and almost immediately reappeared with a small mammal (which I am almost sure was a chipmunk (*Eutamias quadrivittatus* or *E. senex*) as I could see the size of the creature and its tail quite clearly) in its mouth. It returned the way it had gone down and went up into the brush-covered rock slide above the trail. It very soon reappeared so it seems that the food must have been taken to a den or possibly cached, otherwise it would have been eaten on the spot. It came back down through the camp again and then disappeared up the lake. I waited for a long time, but it did not reappear.

The surprising thing about the incident is the apparent lack of fear on the part of the marten. We assume that an animal that is seldom seen by man is afraid of him and so keeps out of his way, but this marten certainly saw me, and the camping equipment and food must have reeked with the smell of man. But the marten pursued its business with no undue haste. Grinnell, Dixon, and Linsdale in "Fur-bearing Mammals of California," indicate that the chickaree may serve the marten as food and its actions in this instance seem to bear this out.—ALBERT C. HAWBECKER, *Madera, California*.

NOTES ON VOLES IN CENTRAL MISSOURI

The observations reported here were made in connection with a study made at the University of Missouri. This involved the capture of 112 specimens (68 ♂♂, 44 ♀♀) of *Microtus o. ochrogaster*, and specimens of several associated species, on 36 plots within a 25-mile radius of Columbia, at various times between October 1942 and April 1944.

Nests.—Above-ground and subterranean nests were found; some were globular but most of them were ellipsoidal. The usual construction was of dried grass, with the centers of finely-matted material and the outer parts of coarser material. Nests found on the surface averaged about 200 mm long, 100 mm wide, and 105 mm deep, while subterranean nests averaged 180 mm long, 150 mm wide, and 100 mm deep. The latter were usually located 2 or 3 inches below the surface; no nest chamber was found more than 5 inches below the surface. Small hillocks of earth and pieces of grass at the entrances of burrows often indicated the presence of underground nests.

Food.—The food of the prairie vole in central Missouri consists of tender stalks of grass and roots, tubers, and fruits of other plants. One underground food store-room, for example, was crammed with 5- or 6-inch clippings of bluegrass. Another, found in a hollow stump in a bluegrass meadow, contained about a gallon of the yellow fruits of the horse nettle (*Solanum carolinense*).

Captive voles ate a great variety of foods. They readily took shelled oats, shelled corn, green grass, clover, lettuce, carrots, tomatoes, and some insects, but soybeans, millet, and lespedeza seeds appeared to be less palatable.

An immature white-footed mouse (*Peromyscus maniculatus bairdii*) was inadvertently placed in a cage containing a large male vole, which, during the night, killed and partly devoured it. On several occasions the heads of trapped voles had been partly consumed before the traps were visited; two of these (January 1944) were in the remains of a haystack where *Microtus ochrogaster* had been the only rodent taken. Evidently the prairie vole is carnivorous at times.

Life span.—The longest periods of live observed during this study were of five adult males:

CAPTURED	DIED	DAYS
Nov. 6, 1942.....	June 7, 1943	213
Nov. 28, 1942.....	Sept. 17, 1943	293
Oct. 24, 1942.....	Oct. 5, 1943	346
March 10, 1943.....	Living when released, March 31, 1944	394
Nov. 28, 1942.....	Living when released, March 31, 1944	488

These data indicate that in captivity the prairie vole may live for at least 16 months, although in the wild it is unlikely to survive so long.

Breeding season in central Missouri.—The prairie vole evidently breeds throughout the year in central Missouri when conditions are like those prevailing in the winter of 1943–1944. In that season the duration of cool and cold weather was longer than usual, but there was relatively little extremely cold weather. A female containing three developing embryos was captured on November 26, 1943. A lactating female, captured on December 8, 1943, had three scars in the left uterine horn. A female containing three embryos in an early stage of development was taken on January 26, 1944. A female containing five well-developed embryos was captured on February 9, 1944. Two immature males, averaging 13.5 grams in weight and apparently born in late December 1943, were taken at the entrances to nest burrows.

Parturition.—The parturition of a captive but wild-bred female *M. ochrogaster* was observed. Although the birth of the first young occurred before the observations were begun. the entire period of birth of the litter probably did not exceed 50 minutes, since only 39 minutes elapsed between the births of the second and the sixth (last) members of the litter.

Small mammal associates.—Besides *M. ochrogaster*, a number of other species of small mammals were taken on the plots: Baird's white-footed mouse, *Peromyscus maniculatus bairdii* (Hoy and Kennicott); northern white-footed mouse, *Peromyscus leucopus noveboracensis* (Fisher); house mouse, *Mus m. musculus* Linnaeus; prairie harvest mouse, *Reithrodontomys megalotis dychei* (Allen); Illinois lemming mouse, *Synaptomys cooperi saturatus* (Boles and Moulthrop); little short-tailed shrew, *Cryptotis p. parva* (Say); large large short-tailed shrew, *Blarina b. brevicauda* (Say); eastern meadow mouse, *Microtus p. pennsylvanicus* (Ord.); Missouri valley mole, *Scalopus aquaticus machrinoides* Jackson; and woodland pine mouse, *Pitymys nemoralis* (Bailey).

Boles and Moulthrop (1942) give the range of *Synaptomys cooperi saturatus* as "Illinois and Indiana, west into eastern Missouri, and east to extreme western Ohio." Missouri specimens examined by them included 16 from Horseshoe Lake and one from Callaway County. In the present study 77 specimens were taken on bluegrass areas in central Missouri near Midway, Boone County, halfway between St. Louis and Kansas City. Forty-six were males and 31 were females. Sixteen specimens were identified by Dr. H. H. T.

Jackson and 61 by the writer. This species may live in the immediate vicinity of *M. o. ochrogaster*, for it has been taken at the same trap-stations as the prairie vole.

S. c. saturatus is especially fond of bluegrass. Bright-green droppings and clippings of bluegrass were frequently observed along their runways. In captivity they ate as much as prairie voles and drank more water. Although they ate grains, they appeared to prefer bluegrass. A female captured on December 5, 1943, contained three developing embryos. Three dead young were found near a bluegrass meadow in June 1943. The species is not easily kept in captivity; the writer's specimens died a short time after being confined. Neither this species nor *M. o. ochrogaster* bred in captivity.—HERBERT J. FISHER, *Columbia, Missouri.*

THE INTERESTING FATE OF A FLYING SQUIRREL

On June 20, 1944, while on a collecting trip in the upper peninsula of Michigan, 9 miles south of Rudyard, Mackinac County, I discovered the body of a Mearns' Flying Squirrel (*Glaucomys sabrinus macrotis*) that had met death in a peculiar manner. A barbed-wire fence ran through the woods where I was trapping, and upon the top wire of this I found the unfortunate creature entangled. A barb had passed through the lateral gliding membrane just in front of the left hind foot. On attempting to free itself the squirrel had spun around the wire several times thus wrapping the skin further around it and making escape more hopeless. The skin at that point was badly torn. The incisors were broken down, evidently from futile assaults upon the metal. The wire was about 3½ feet off the ground.

Much of the best lumber had been removed in the area and there were no very large trees immediately adjacent to the scene of the accident although a grove of larger timber was situated nearby. I could not see any sizeable trees toward which the squirrel might have been aiming unless it was one of the numerous small saplings. The squirrel must have been nearing the ground at the termination of its glide and struck the fence where it perished. It had been caught recently as despite the warmth of the weather no signs of decay or slipping of the fur were evident. The specimen was an adult female and nursing young.—JAMES S. FINDLEY, *2645 Fairmount Blvd., Cleveland Heights, Ohio.*

REACTIONS OF A RHESUS MONKEY TO EMBALMED CORPSES

During research for my doctorate, I had occasion to make use of two embalmed and considerably dissected human cadavers, which I kept under tarpaulins in a laboratory room. At this time I had occasion to bring the cage of a rhesus monkey into this same room. This monkey had been wild, afraid of everything new and inclined to bite, but by this time had gotten thoroughly tame. Ordinary novelties no longer frightened nor specially excited him. I wondered what his reactions to uncovering of the cadavers would be. The strong smell of embalming fluid in the room had not appeared to arouse in him more than a momentary curiosity shown by his endeavor to get as close to the cadavers' table as possible.

When I unveiled the cadavers the monkey's reaction was much stronger than he had shown to any new object for weeks past. He drew back and took his customary attitude when anything frightened him. He also did something distinctly unusual for him, looked at the cadavers, then looked fixedly at me, then back and forth again several times. If a human being had acted thus, one would have thought that he was speculating on some resemblance or other connection between the cadavers and a living man. While at this time he usually promptly went up to any new object, he hung back when I tried to get him to approach the cadavers. He finally approached in a very cautious manner, his attitude seeming to indicate not only fear but some other kind of strong excitement. At last he suddenly nibbled at the toes of one of the cadavers and curiously enough thereupon seemed reassured. His fright pose disappeared and most of his interest. Thereafter he acted as if the corpses were now common place to him.

Why should the first sight of the cadavers have so frightened him when at this time other new objects did not? It would be worthwhile to confront not only other monkeys but gorillas, chimpanzees, and orangs with cadavers and see what their reaction would be. Is there something calculated to arouse fear in a mind free from our human associations of death in an embalmed partly dissected corpse? A correspondent of mine states that in the first World War he repeatedly saw horses shy away from the vicinity of their dead comrades and avoid passing at close range.—JOHN E. BAUMAN, *Rio Grande, Ohio.*

OBSERVATIONS ON THE TREE-CLIMBING HABITS OF THE CALIFORNIA GROUND SQUIRREL

The tree-climbing habits of the California ground squirrels (*Citellus beecheyi*) are well known by the almond and prune growers of the Sacramento Valley, California. It is frequently necessary to employ preventive measures to keep these large ground squirrels from climbing the trees and cutting large quantities of the green fruit.

Even with knowledge of these orchard depredations, I was surprised recently while making a census of the California gray squirrel (*Sciurus griseus*) to find how frequently I mistook the ground squirrels for the gray squirrels in the tree tops until my field glasses were brought into use. Ground squirrels were frequently observed 60 or more feet from the ground in the 2400 acre native oak Bidwell Park near Chico, California. Although not nearly as agile as are the gray squirrels, the ground squirrels experience no difficulty in driving them away from their preferred arboreal routes. The ground squirrels frequently use these tree rôutes where the tips of the branches of neighboring trees are contiguous. No ground squirrel was ever seen to jump from branch to branch. In these relatively tall trees none was ever observed to run to its burrow in the earth to seek shelter from a potential enemy. One ground squirrel was observed while eating samaras in a maple tree 40 feet from the ground. On April 18, about 15 minutes after sun rise a large ground squirrel was seen to emerge from a hole 20 feet up in a living tree where it had spent the night. It sunned itself several minutes then climbed far out on a branch where it prevented two gray squirrels from using the tree as an arboreal route. Later, using an arboreal route, it crossed the creek and came to the ground to feed.—LLOYD G. INGLES, *Fresno, California.*

PARASCALOPS TUNNEL IN USE AFTER EIGHT YEARS

Arlton (Jour. Mamm., vol. 17, p. 355, 1936) states that while many of the burrows of *Scalopus aquaticus* are used only once, some are used frequently and for a considerable time. A mole used one tunnel throughout a whole summer. It was his belief that some tunnels must be used for years; especially those along fences and those placed where the vegetation consists of sod-forming plants which help to keep the tunnels intact. Eadie (Jour. Mamm., vol. 20, pp. 153–154, 1939) in describing the tunnels of *Parascalops* states that some of the tunnels are used for a considerable period. Upon the thawing of the ground in the spring some of the tunnels in use the previous season are repaired. Neither of these authorities give any precise data on the permanence of mole burrows.

In 1936, my brother, Dr. Paul A. Wright, and I found several tunnels of *Parascalops breweri* near our home in Nashua, New Hampshire. The tunnels were located where they crossed foot paths in an area of dense brush of scrub oak, aspen, hawthorne, and various other species. We trapped these tunnels by opening them and setting small mouse traps at right angles, flush with the bottom of the tunnel and covering the opening with a piece of tar paper. We obtained specimens of *Parascalops*, *Pitymys*, and *Blarina*. Some of these tunnels were still in use in the summer of 1937 and I obtained more specimens of the same species. Two of these runways were used extensively by many individuals, since I obtained nine *Blarina* and two *Parascalops* from a single trap in a 10-day period.

In September 1944, I again searched for these tunnels. I was unable to find most of them because they were apparently no longer extant, but one was still covered by the piece of tar paper used in the trapping in 1937. A trap placed in this tunnel yielded one *Parascalops* and two *Blarina* in a 4-day period. This particular tunnel was located in soil with a

very heavy growth of roots in the sod, which undoubtedly helped to preserve it but undoubtedly made the construction of additional tunnels difficult. It is not thought that this use of a single tunnel over such a long period is unusual, but the failure to find such evidence in the literature prompts the publication of this note.—PHILIP L. WRIGHT, *Department of Zoology, Montana State University, Missoula, Montana.*

ACCOUNT OF A WEASEL IN A TREE

While looking through some back volumes of the *Journal Mammalogy*, I noted one record of a weasel being found in a tree. This recalled to my memory a similar experience that I had in 1935, which may be worthy of note.

While I was out looking for new arrivals among the spring birds of the Walla Walla Valley of southeastern Washington, I heard an unusual commotion made by a family of red-shafted flickers not far away. I was curious as to reason for this, so went to see. I looked up into a dead tree and saw a large male long-tailed weasel (probably *Mustela frenata effera* Hall) trying to get into the nesting cavity of the flickers. The flickers must have had either eggs or young, and protested the weasel's attempts violently. The birds dived at the weasel, but he turned his head so menacingly toward them that they dared not get too close. They were keeping the weasel from entering the nest, however.

I decided it would be interesting to climb the tree and chase the weasel into the very top. I did this, and I had a thrilling time for a few minutes. At first the weasel just looked at me and showed his teeth. Then, when I tried to come closer, he pretended that he would jump to the next tree, which was really too far away even for a squirrel. Seeing that he could not jump to safety, he tried bluffing me by pretending that he was going to charge full force at me. When I did not retreat, he backed up into the high branches again, evidently to think over the situation. We stood there for some time looking at each other; he also looked at the ground some 30 feet below. I thought for awhile that the weasel was going to jump to the ground, but he must have thought better of that idea. I finally decided to kill the animal with a stick that I had broken off. I advanced slowly toward him. Now he seemed to sense that I meant business, so he decided to rush past me down the tree. He braced himself for a moment, then with all the speed he could muster, he rushed headfirst down the tree past me. I was hardly prepared for his sudden move, and when I swung at him with the stick, I missed, but hit the tree so hard that I knocked him to the ground.

I hurried down the tree as fast as I could, trying to reach the animal before he gained consciousness. The fall knocked him out for about a minute. When I was nearly to the ground, he came to and hurried off through the weeds.

Even though I did not get the weasel, I will always remember his looks as we stared at each other 30 feet above the ground in a dead tree, with a pair of angry flickers doing all they could to get rid of both of us.—ERNEST S. BOOTH, *Department of Biology, Walla Walla College, College Place, Washington.*

WILDCAT PREDATION ON DEER

Most people are of the opinion that wildcats do not kill deer. Certainly nothing could be farther from the truth for the evidence of tracks in the snow and examination of wildcats collected in eastern Maine indicate that deer and rabbits form a large part of their diet.

Last winter I found the tracks of a wildcat on a newly fallen snow. I had followed these tracks but a short distance when I saw where the cat had run onto a snowshoe rabbit which it chased, caught, and ate except for a small part of the intestines. The cat's tracks then led away from its kill into a cedar swamp where it jumped two deer. The cat evidently followed these deer and tried to catch them. A short time later my companions killed this cat, a small one, weighing 18 pounds. We examined the contents of the stomach and found that it had eaten the rabbit almost in its entirety, including ears, eyes, teeth, and skin. One might suppose that the cat would have been satisfied after it had killed and eaten the rabbit, but the cat's tracks showed that it had followed the deer and tried to catch them.

Apparently wildcats will chase both rabbits and deer like a dog, although the cat makes little noise. Wildcats also hide and pounce upon their prey from ambush.

When a wildcat kills a deer it usually eats what it wants and then paws snow, dirt, or anything handy onto the carcass to cover and conceal it. Wildcats usually eat the steak from one of the hind legs first, although sometimes they eat from the forward shoulder. Occasionally they return for a second feast from their kill, but I believe this is the exception, not the rule, when prey is plentiful. They seem to like best fresh blood and warm meat.

On December 8, 1943, in company with Patrolman Stanhope, I found a fawn weighing 73 pounds killed by a wildcat sometime during the night or day before. This fact was established by the signs in the snow, which fell 18 hours previous to the time we found the dead deer. Tracks in the new snow clearly indicated where the kill had taken place. We were curious as to why the cat didn't eat any of the deer and, back-tracking the cat a short distance, we found the answer, another dead deer, evidently the mother of the fawn we had found earlier. Tracks in the snow clearly showed where the cat had killed the mother deer, eaten what it wanted off her hind quarters and then proceeded to kill the fawn, which evidently had waited around for its mother.

Chief Warden Clark called on me that evening, and together we examined the first deer we had found to ascertain just how the cat had killed its prey. So far as we could see there were no visible signs of how the deer had been killed. Very carefully, therefore, we shaved the hair from under the deer's throat, and we found two teeth punctures on each side of its throat. The incisions were not back far enough to puncture the jugular vein, but they were placed just right to go around the windpipe like a vise. Obviously, the cat had shut off the supply of air to the lungs, killing the deer by strangulation (see fig. No. 1). We removed the hide from the carcass to find any other marks that would assist in determining just how the cat, biting the deer's throat, held or clung to the larger animal. On the left side, just back of the front leg, we found lacerations that looked like claw marks, and although the flesh was badly torn, the cuts were not sufficiently deep to reach the heart or any other vital organ. As all the claw marks were on one side, we decided that the cat had wrapped its front legs at least partly around the deer, hanging on by its claws while it bit the deer's throat.—Bertrand E. Smith, *Moosehorn National Wildlife Refuge, Calais, Me.*

DEPREDATIONS OF A GRAY SQUIRREL

On March 31, 1945, I went to my camp at Little Duck Pond, in Windham, Maine, for the first time since leaving it the previous November. As I entered through the back door, the first thing that attracted my attention was quite a number of wooden chips and a bottle on the floor, which were not there when the camp was closed. Passing from the kitchen to the combination dining and living room, a scene of havoc and destruction met my eyes. Filth and broken glass and china covered the floor. Quite a number of unbroken articles were also on the floor.

Before I closed the camp last fall, I had gathered two large bags of pine cones and left them beside the open fireplace, and a 10-quart pail nearly full of apples on the floor. The cones had all been picked to pieces and a heap several inches high and two or three feet in extent covered the floor in front of the fireplace. All the apples had been eaten, except for the skins which were scattered on the floor. In the back end of the living room on a built-in bunk, which had been covered with an Indian blanket, and on which were a number of sofa pillows, lay the apparent cause of the damage—a large gray squirrel, dead and stiff. It must have starved to death or died of thirst. The blanket was chewed so full of holes that it was ruined. The down filling of one pillow had been pulled out and the mattress at the spot where the squirrel lay was thoroughly saturated with filth.

Worst of all, the window sashes of practically all of the windows in the cabin had been gnawed on the sides and bottom, almost to the glass; the window sills were badly gnawed; and the sash curtains had been chewed to rags. The gnawings from the window sills added

to the mess on the floor. It seems almost incredible that one squirrel could have done that amount of gnawing.

On the mantel and on shelves in the room I had had many pieces of antique china and glass. Evidently, in efforts to find a way of escape, the squirrel had been all over these shelves, knocked the articles off, and broken many of them and in desperation had endeavored to gnaw out at the windows. The back door has a glass panel more than three feet above the floor. The lower part of the glass casing on the inside had been gnawed in the same manner as the window sashes. It would seem that the only way possible for the squirrel to have gnawed this would have been by jumping from the floor or from a chair near the door and biting a piece out of the wood each time. I could see nothing on which he could rest his feet, or in which he could fix his claws, while doing it. It became apparent that the squirrel had come down the fireplace chimney, pushed away the fire screen, gotten inside, and was then unable to find his way out.

Previously, I have always had a rather kindly feeling toward gray squirrels, but this extravaganza of destruction has changed my mind. I shall be sure to take steps to prevent the recurrence of the depredation.—FREDERIC J. LAUGHLIN, *191 Pine St., Portland, Maine.*

THE TYPE OF SCIURUS TEXIANUS BACHMAN

A number of years ago (1906), by considerable effort and some expense, I visited European museums and made careful examination of various specimens forming the basis of early descriptions of certain North American mammals. The object was to eliminate, so far as possible, the personal equation in interpreting the descriptions of authors who did not designate types and who frequently confused several species or subspecies as later understood. As I have said elsewhere (Jour. Mamm., vol. 9, p. 53, 1928), "Such descriptions have tried the souls of conscientious taxonomists for years, and whenever an actual type specimen has appeared in their history, it has been seized upon as a godsend."

It is somewhat disconcerting, therefore, to find that, at least in one case just brought to my attention, my conclusions have been challenged on the basis of a lengthy analysis of the description and other literature rather than upon a reexamination of the specimens concerned. This would be unimportant if it did not contravene a most useful taxonomic method which has come to be well recognized and extensively practiced, that is, the designation of lectotypes.

In their "Revision of the Fox Squirrels" (Occas. Papers Mus. Zool., La. State Univ., No. 9, pp. 155–172, 1942), Lowery and Davis have seen fit to consider my choice of a lectotype for *Sciurus texianus* as unwarranted and, although they do not seem to realize it, they have in effect merely made another choice. This they do in the conviction that the specimen which I chose does not sufficiently conform to the description. If I agreed with this, I might reply that the one they have chosen conforms still less. However, I do not agree and see no reason to alter my original statement which was as follows: "Of the specimens mentioned by Bachman, I have lately examined the one in the Paris Museum and the one in the British Museum and am convinced the latter should be considered the type. It agrees perfectly with the description, which was doubtless prepared as well as published in London, and, moreover, it must be the specimen exhibited at the meeting of the Zoological Society in the report of which the name was proposed" (Proc. Biol. Soc. Wash., vol. 20, p. 46, 1907).

Bachman's description (which is complicated by being rendered in the third person) states "ears on both surfaces, yellow with interspersed *white* hairs; *nose* and lips brownish *white*." My own description of the lectotype seems sufficiently similar, saying "The forehead and nose are bare of hair except a little patch on the nose which is soiled *white* and from this I should judge that the nose *was* extensively whitish. The ears are ochraceous, of a paler shade than the surrounding parts, even inclining to *whitish* in places." Evidently Bachman recognized some white on the ears and the condition of the specimen may have led him to underestimate the extent of white on the nose.

The two specimens under discussion are the only ones for serious consideration. Casual mention is made of specimens in the museums of Berlin and Zurich which "he conceives to be the same species" and there is reference to notes taken from "a specimen received by a friend from the south-western parts of Louisiana." The specimen in the Paris Museum carries on its label the word "Type," but on the bottom of its wooden stand this appears as "*probl'. le type.*" Both were doubtless written long after Bachman and were not published until they were quoted by myself after having designated the British Museum specimen as lectotype. Therefore they have no force and, as shown by my examination, the specimen itself is in pronounced disagreement with the description.

Lowery and Davis give the impression that they regard the description as composite and that neither specimen can be taken as type, saying "In reality, little is to be gained by attempting to choose at this late date which specimen Dr. Bachman himself considered the type." Of course Bachman had no idea of an individual type in the modern sense; but since his material is still existing and has been examined, it is according to regular practice to regard one of his specimens as a lectotype to all intents and purposes serving as if it were an originally designated type. American mammalogists have had less occasion to deal with such matters than Europeans, especially the British. Oldfield Thomas, whose experience exceeded that of any other modern mammalogist, was especially impressed with the value of such selections and published a series of papers in which many lectotypes (or lectoparatypes) were designated.

Of course a specimen that was not in the describer's hands or one that seriously disagrees with his description cannot be taken as a lectotype. In this case it seems clear that the British Museum specimen was the principal basis of Bachman's name and it does not seriously disagree with the description. In fact, if we assume that the absence of hair on the nose may have misled Bachman as to the natural extent of white, it does not disagree at all.

Lowery and Davis lay great stress on the white ears and nose, even going so far as to suggest that I had suppressed a remark (opinion rather than description) by Bachman following his description in which it is inferred that his *texianus* differed from *capistratus* (= *niger*) in the amount of white on the nose. So it did, from his standpoint, and so it does now if one has only the lectotype from which to judge. In my description of this lectotype I emphasize the fact that the ears are "inclining to whitish in places" and that the nose, so far as hair remains on it, is "soiled white." This is essentially what Bachman says in his description. Moreover, I expressed the opinion that the nose probably was at one time "extensively whitish" which should be sufficient to excuse me of any intentional obliquity. Far from minimizing the white, I emphasized it.

The repeated statement that the form to which I have applied the name *texianus* "always" has the nose and ears white is not fully borne out by specimens in the Chicago Museum. One of these, taken in late May in St. Tammany Parish, Louisiana, has the ears wholly ochraceous without trace of white. Another taken in August, has the ears rather thinly haired, but without obvious white. In winter pelage, nose and ears are doubtless always white, but in summer at least the ears may be plain ochraceous.

In disposing of the name *texianus* as a synonym of *ludovicianus* Lowery and Davis imply the Paris specimen as the basis of the name, apparently in this case being quite willing to overlook its pronounced disagreement with Bachman's description. Their statement that *texianus* "now proves to be a synonym of *Sciurus n. ludovicianus*" leads one to wonder what they consider as proof. The specimen is chiefly pale gray in color with wholly white under parts. This coloration is sometimes seen in *S. n. neglectus*, but positive identification seems unlikely except by careful and direct comparison. The localities assigned to any such old specimens in most cases are of course wholly untrustworthy.

For the form to which I have restricted the name *texianus* Lowery and Davis have proposed the new name *bachmani*. This, it seems to me, is quite unjustified and the name *bachmani* should be regarded as a synonym of *texianus*.—WILFRED H. OSGOOD, *Chicago Natural History Museum.*

THE PERFUME-GLAND OF THE BINTURONG (ARCTICTIS)

In her description of the gland in this viverrid, published in the February issue of the Journal of Mammalogy, which reached me April 10, Elizabeth Story quite justly criticises me for the mistake I made 30 years ago regarding the positional relations between this gland and the generative orifice in the female. Her comments, however, struck me as being a little unkind, since I myself corrected the error, which had been known to me for at least 20 years, in my Mammals of British India, vol. 1, p. 431, 1939. I do not feel flattered by the thought that there is presumably no copy of this volume in the library to which Miss Story had access.—R. I. Pocock, *British Museum (Natural History), London.*

RECENT LITERATURE

(Conducted by Gerrit S. Miller, Jr., Remington Kellogg, and Emma M. Charters)

[Copies of this section may be purchased from the Corresponding Secretary]

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COMMENT AND NEWS

ANNUAL MEETING APPROVED

The first post-war meeting of the American Society of Mammalogists is scheduled for April 18–20, 1946, at Pittsburgh, Pennsylvania. Now that travel restrictions are in large measure behind us, and many of the members formerly in service are again civilians, the time is ripe for a "Reunion of Mammalogists." Members of the Society are urged to lay plans *now* to attend and participate in the program. Arrangements for the meeting are in the hands of a committee headed by J. Kenneth Doutt, Carnegie Museum, Pittsburgh. Write to him or to Dr. Emmet Hooper, Museum of Zoology, Ann Arbor, Michigan, and request a spot on the program. Let's make this an outstanding meeting.

DALQUEST TO WORK IN MEXICO

Walter W. Dalquest has accepted a position at the Kansas Museum of Natural History and is scheduled to carry on field investigations of vertebrates in Mexico during 1946. His work will be concentrated in the state of Veracruz.

HOOPER RETURNS TO MICHIGAN

Dr. Emmet T. Hooper returned to active duty at the University of Michigan in December after serving more than two years in the Army Air Corps. He will resume the duties of Corresponding Secretary of the Society, which work was handled by Dr. W. H. Burt during his absence.

OBITUARY NOTICE

It is with deep regrets that we report the deaths of the following members of the Society:

George Willett, Los Angeles Museum, Los Angeles, California, on August 2, 1945. Mr. Willett had been a member of the Society since 1935. Although primarily an ornithologist, he was a keen student of mammals.

Dr. Francis Bertody Sumner, Scripps Institution of Oceanography, La Jolla, California, on September 6, 1945. Dr. Sumner was a charter member of the Society and gained much of his reputation in the study of geographic variation and heredity in the deermouse.

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[Prepared by HENRY W. SETZER]

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